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OBSERVATIONS ON THE DISTRIBUTION AND DIVERSITY OF TREE FERNS IN THE ZONA RESERVADA DE TAMBOPATA, MADRE DE DIOS, PERU

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Key words: tree ferns, distribution, diversity, Amazonia, Peru, tropical moist forest

ABSTRACT

The distribution and diversity of tree ferns was investigated in the Zona Reservada de Tambopata, an area of Tropical Moist Forest in the Amazon basin of South-east Peru. Tree ferns were found to be patchily distributed along the banks of forest streams within the reserve. Diversity of tree ferns is surprisingly high at the site, with four or possibly five species of Cyatheaceae collected during the present study, plus an additional four species previously recorded.

INTRODUCTION

Tree ferns of the family Cyatheaceae are a feature of many tropical forests, being particularly characteristic of wet montane and cloud forests (Tryon & Tryon 1982). They are generally regarded as light gap pioneers, associated with ravines, canopy gaps and other relatively open situations, although there have been few detailed studies of their ecology and distribution (Gomez 1983).

A study was carried out to assess the distribution and diversity of tree ferns in the Zona Reservada de Tambopata (ZRT), located in the upper Amazonian basin of South-East Peru at 12° 50' S and 69° 18' W (Fig. 1).

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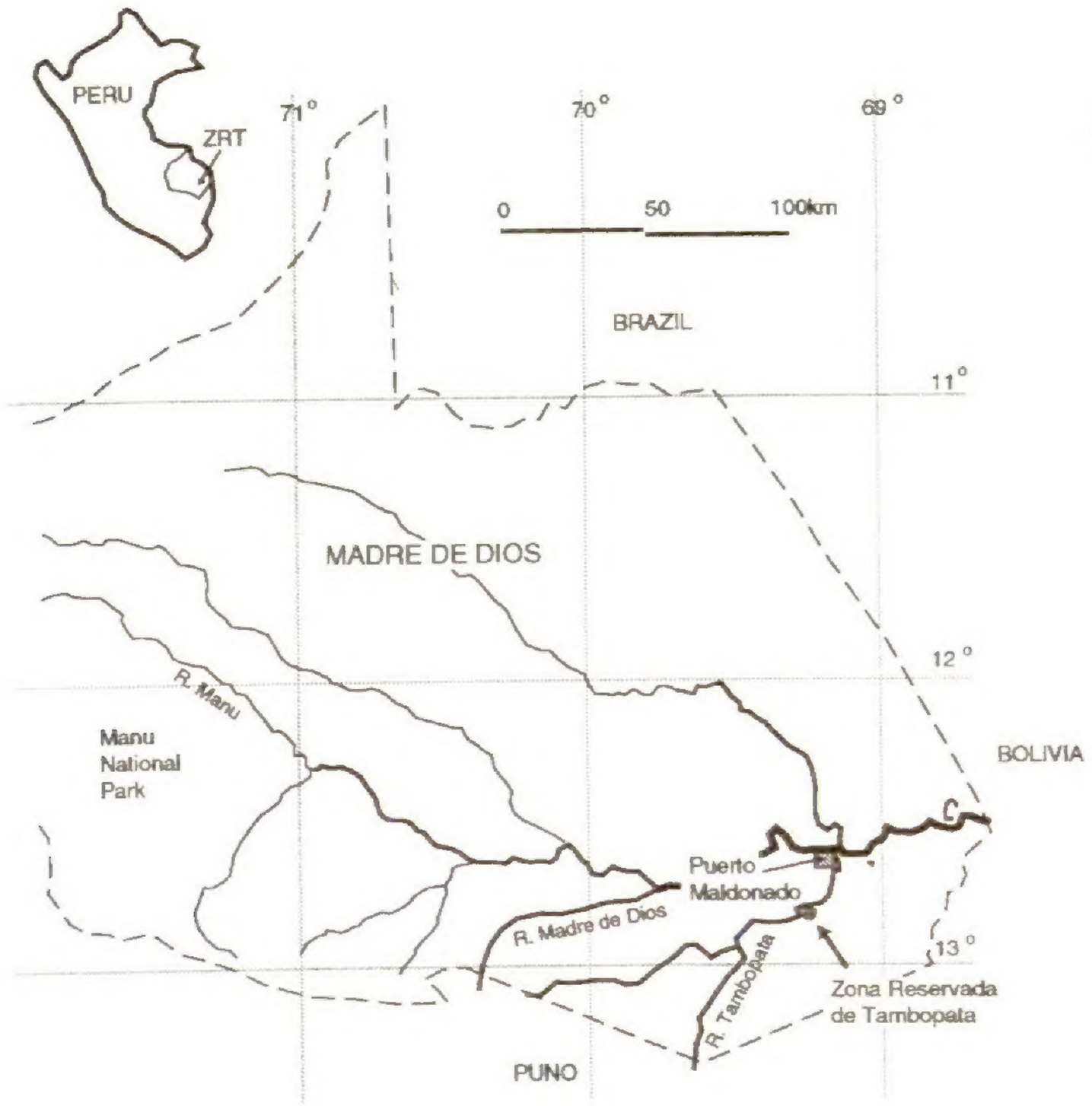

Figure 1: Location of the Zona Reservada de Tambopata

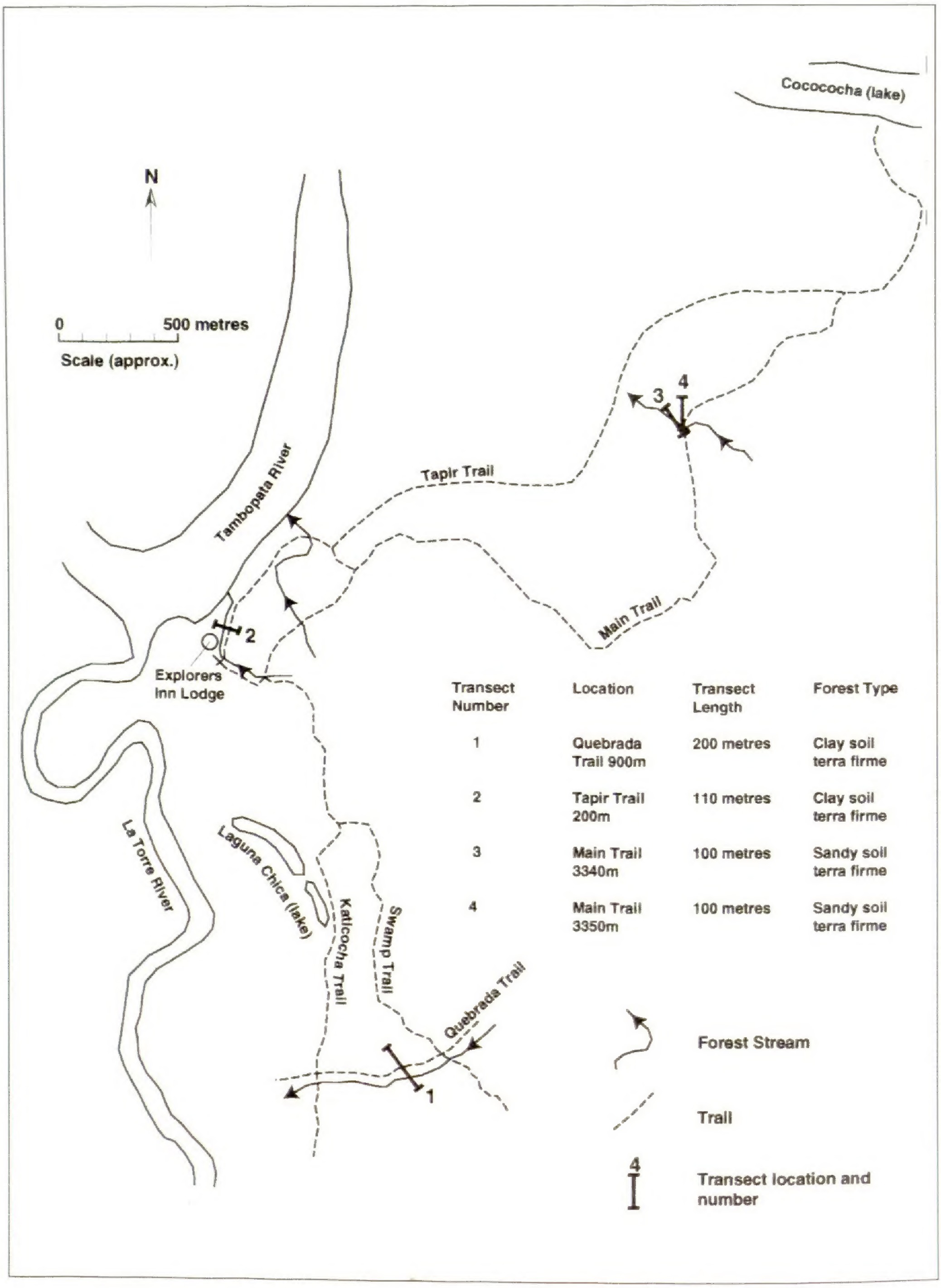

Figure 2: Sketch map of the Zona Reservada de Tambopata, showing location of transect samples

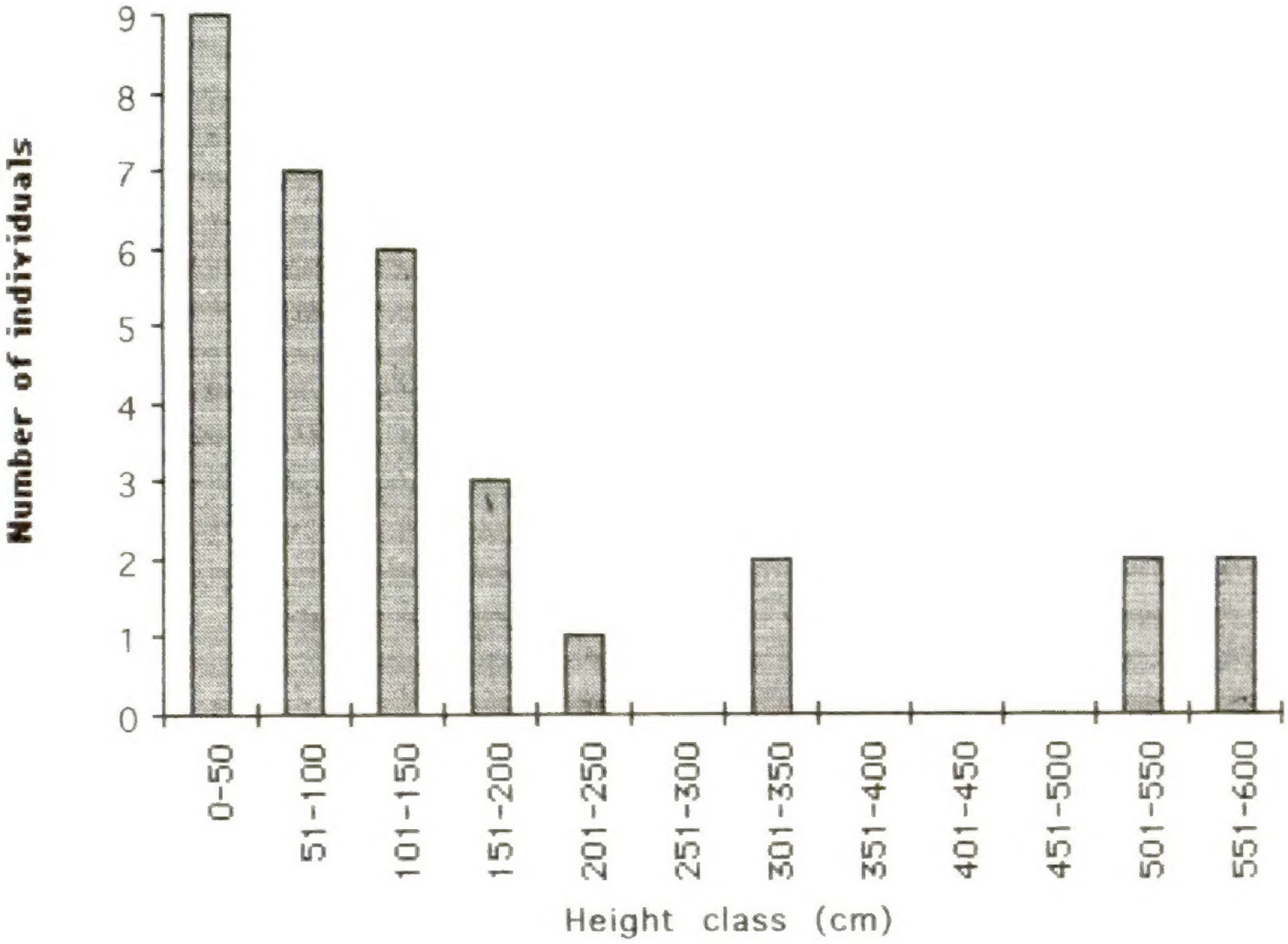

Figure 3: Height distribution of *Nephelea cuspidata*

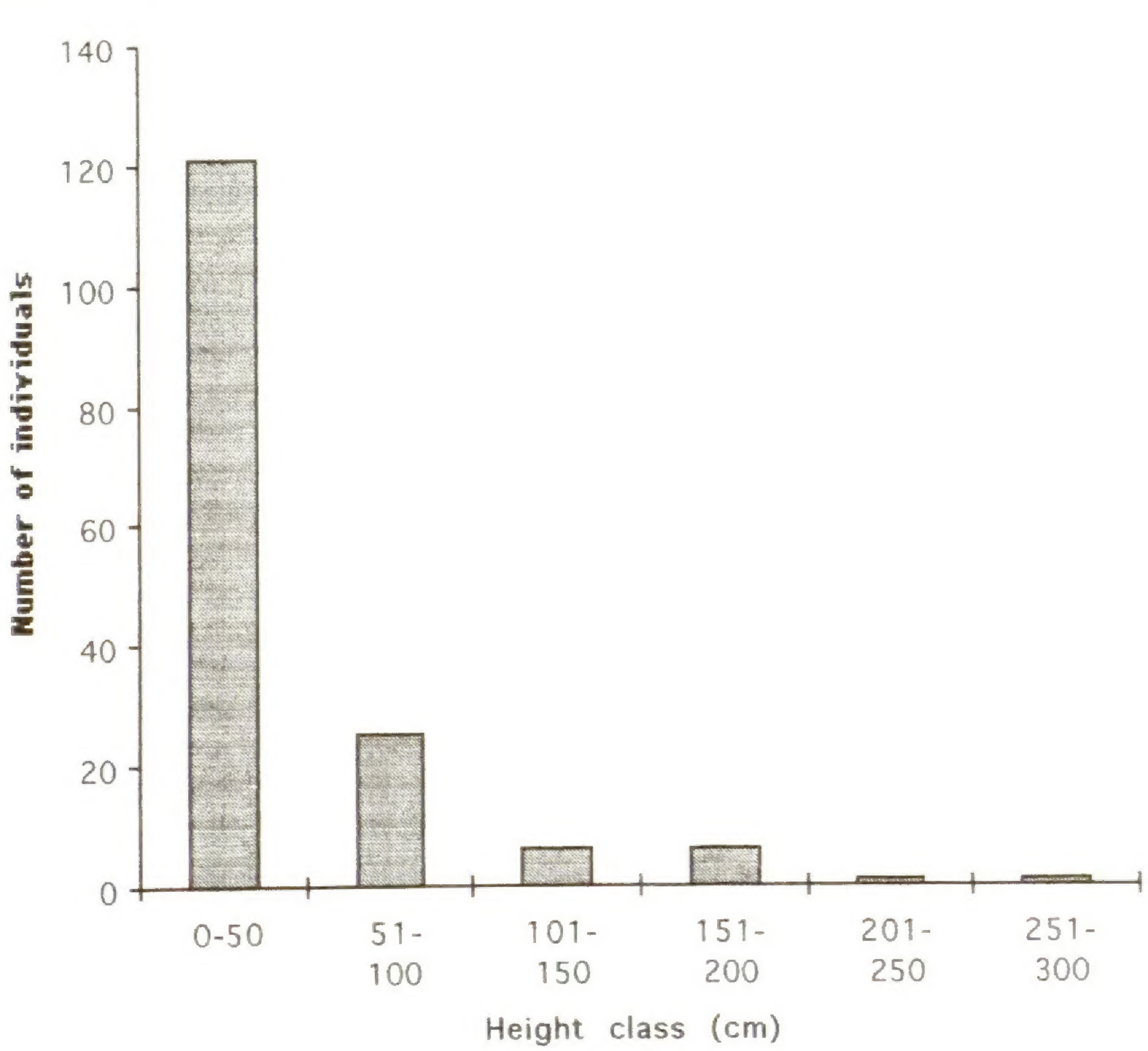

Figure 4: Height distribution of *Trichipteris/Cyathea* complex

Covering an area of 5500 hectares, the reserve supports a lowland tropical moist forest formation at an altitude of 260 m (*sensu* Holdridge *et al* 1971). Mean annual precipitation is around 2000mm, with a dry season extending from May to October. Annual average temperature is 25.2°C, but temperatures may drop to as low as 8°C during occasional dry season cold spells (Phillips 1993). Since its establishment in 1977, the reserve has been intensively studied and has been shown to support exceptional levels of biodiversity (see for example CDC 1995, Erwin 1988, Gentry 1988, Stewart 1988).

METHODS

The study was carried out between August and September 1990. A systematic search for tree ferns was made along the extensive trail system of the reserve, traversing a variety of floodplain and terra firme forest types (*sensu* Erwin 1984, Phillips *et al* 1994). A collection of tree fern specimens was made and deposited at the Herbario San Marcos (USM) of the Museo de Historia Natural Javier Prado in Lima, Peru, where they were later identified by Ms Blanca Leon.

The majority of tree ferns encountered were found to be associated with forest stream systems. Quantitative sampling was undertaken in order to investigate this relationship further. A series of four belt transects were laid out perpendicular to forest streams, each transect traversing the stream channel, its banks and continuing some distance into adjacent, undisturbed forest (Fig. 2). Transect length varied from 100 to 200 metres and each consisted of a belt of contiguous 5 metre x 5 metre quadrats. The following variables were recorded from each quadrat:

1. Number and provisional identity of any tree ferns
2. Height of each tree fern
3. Slope gradient
4. Canopy cover above the centre of the quadrat, measured using a spherical densiometer.

RESULTS

Five species of tree fern were collected during the study. Three were positively identified to species level:

Nephelea cuspidata (Kunze) Tryon

Trichipteris procera (Willd.) Tryon

Trichipteris pilosissima (Baker) Barr.

The fourth species could not be adequately resolved between *Trichipteris nigripes* (C.Chr.) Barr. *sensu lato* and *Cyathea tortuosa* R.C. Moran., whilst the fifth was tentatively assigned to *Cyathea* (B. Leon, pers. comm.).

Nephelea cuspidata is the largest and most majestic of the Tambopata tree ferns. The tallest individuals reach a height of 5.5 - 6 metres, although the population is dominated by smaller individuals (Fig. 3). All of the 33 plants examined were growing on stream banks in clay soil terra firme forest, suggesting that the species may be confined to this habitat at Tambopata.

Only a single individual of *Trichipteris pilosissima* was encountered during the study. This measured a height of 0.47 metres and was found growing on the edge of an old floodplain bench in mature, closed canopy alluvial floodplain forest.

The other tree ferns could not be safely separated in the field and were treated as a species complex for the purposes of the study. These ferns, presumed to be mostly *Trichipteris procera*, but also including *T.nigripes/Cyathea tortuosa* and the unresolved *Cyathea* species, were relatively abundant, with a total of 160 individuals enumerated. They are generally small to medium sized tree ferns, with the tallest plant recorded having a height of 2.6 metres. The population is again dominated by individuals in the smallest size classes (Fig. 4). Plants of this species complex were occasionally found in undisturbed forest but most individuals were

concentrated along the banks of streams, in this case in both clay soil and sandy soil terra firme forest.

Transect data confirm the concentration of tree ferns along the banks of forest streams (Figs 5a - d). Tree ferns were entirely confined to the stream banks in three of the four transects. They were found away from streams only in transect number 1 (Figure 5a), where scattered populations of the *Trichipteris - Cyathea* complex were encountered up to 70 metres from the stream bank, growing under a closed forest canopy (<95% cover). This general pattern was confirmed by the systematic searches for tree ferns. Out of a total of 193 tree ferns found in the study (including transect data), 89.1% were growing along the edges of stream systems.

DISCUSSION

Tree fern diversity at Tambopata is apparently high for a lowland rainforest site. In addition to the four, possibly five species encountered in the present study, the reserve checklist (Anon 1989) lists two other members of the Cyatheaceae, namely *Cyathea multiflora*, and another undetermined species of *Cyathea*. Stolze (pers. comm.) has records of *Cyathea andina*, *Nephelea cuspidata* and *Trichipteris nigripes* from the reserve. The total of six plus species for the reserve compares favourably with the five species recorded in an extensive study of montane rainforests in North-Central Peru at an altitude of 2700-3700 m (Young & Leon 1991) - a more typical tree fern habitat. In contrast, a study of lowland wet tropical forest, at an altitude of 350 m, in the Central Peruvian Amazon catalogued only a single species, *T. nigra*, although in this case only a small (2 hectare) area was studied (Young & Leon 1989). The high levels of tree fern species richness at Tambopata may be a function of its relatively close proximity to the Andean region. The presence of an Andean element in the Pteridophyte flora of the nearby Brazilian state of Acre (including *Nephelea cuspidata*), has been previously remarked upon by Tryon & Conant (1989).

Tree ferns are often regarded as light gap pioneers (Gomez 1983). The concentration of tree ferns along forest streams at Tambopata would seem to support this view. Tambopata forest streams are generally deeply incised, with steep banks subject to frequent disturbance. Tree falls are common along stream margins and canopy cover (mean 85%) is generally lower than adjacent areas of closed forest (mean 92%). However, the difference is not statistically significant ($F = 1.87$, p 0.01) and tree ferns were frequently to be found growing under relatively heavy canopy cover (< 95%), suggesting that light climate is not the primary factor determining tree fern distribution. Perhaps more important is the availability of suitable regeneration niches, with the disturbed stream banks providing relatively large areas of recently bared and generally moist soil, suitable for the development of gametophytes and sporophytes. The high moisture requirements of tree ferns have been noted by Gomez (1983), the availability of water being critical to the success or failure of gametophytes and subsequent plantlets. Microclimatic influences may also be involved, although a limited study of microclimate carried out by the author at Tambopata in 1993 did not reveal any discernible difference between stream bank and forest interior locations in terms of either temperature or relative humidity.

Tree fern height class distributions at Tambopata are dominated by small individuals, with relatively few tall, mature plants. Similar height class distributions have been described by Young & Leon (1989) for a population of *Trichipteris nigra* growing in the Central Peruvian Amazon and by Seiler (1984) for *Nephelea tryoniana* in El Salvador. Young & Leon (1989) suggested that the smaller size classes suffered either high mortality or growth suppression and that only a few individuals were able to grow to maturity. Either or both processes - which are not necessarily independent of each other - could explain the observed height distributions at Tambopata and further work is required to elaborate on these issues.

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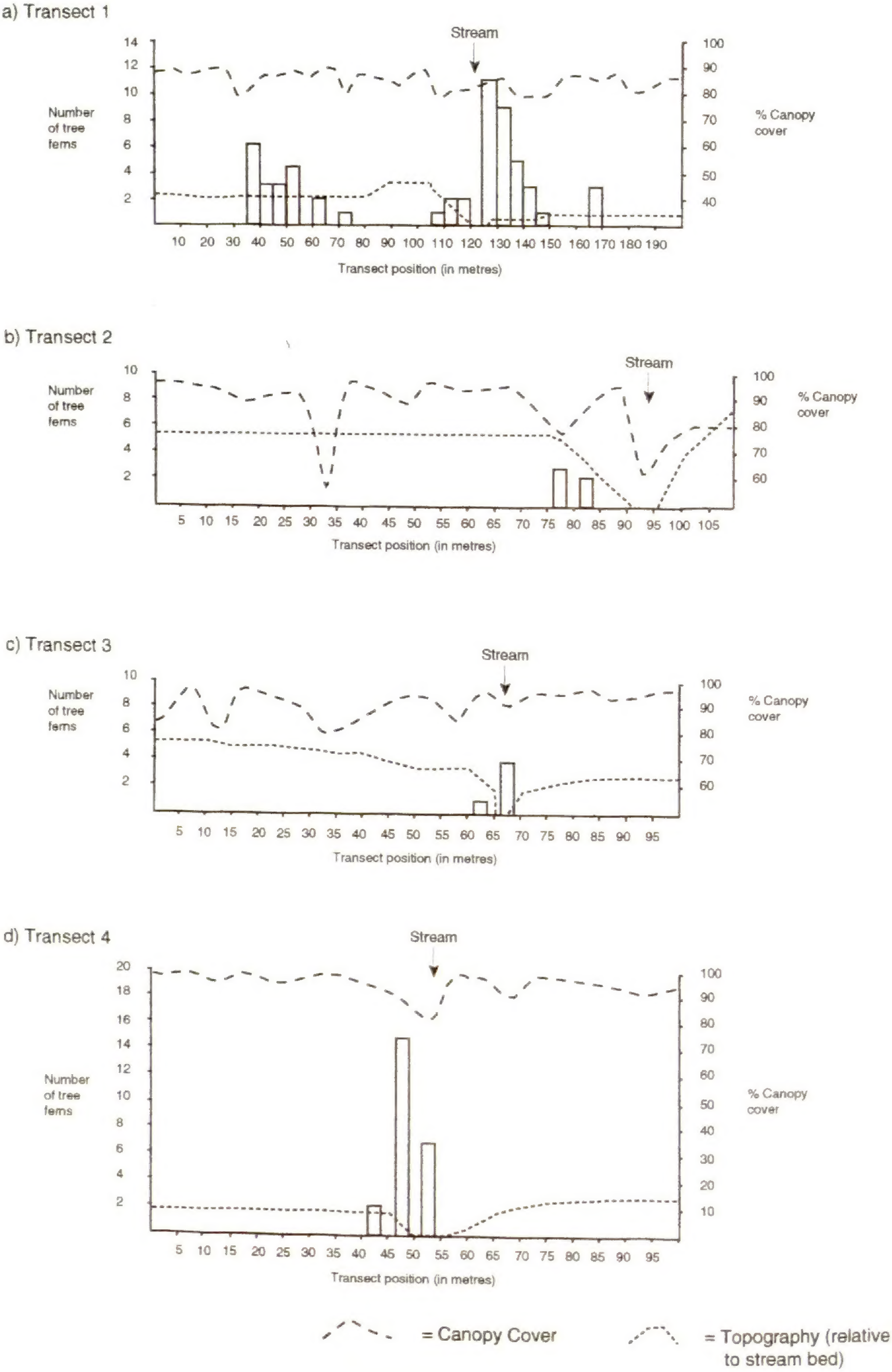

Figure 5: Distribution and abundance of tree ferns

Isabel Bohorquez and Blanca Leon, of the Museo de Historia Natural Javier Prado, Lima, Peru provided invaluable advice and support. Clive Jermy and Robert Stolze kindly read the original field report from the study and gave many helpful comments.

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ROOT ANATOMY OF ASPLENIACEAE AND THE IMPLICATIONS FOR SYSTEMATICS OF THIS FERN FAMILY

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Key words: *Asplenium*, *Hymenoasplenium*, root anatomy, systematics, phylogeny

ABSTRACT

The root anatomy of about 140 species of Aspleniaceae have been studied including members of *Hymenoasplenium* and nearly all satellite genera of *Asplenium* such as *Ceterach*, *Diellia*, *Loxoscaphe* and *Pleurosorus*. The division of the family into two genera, *Asplenium* and *Hymenoasplenium*, is supported by characters of the root cortex. The occurrence of sclereids with an eccentric lumen (asplenium-sclereids) distinguishes *Asplenium* from *Hymenoasplenium* as well as from all other ferns. Root anatomical characters are mostly constant at the species level and therefore they are an appropriate marker for species groups of *Asplenium*. A probably monophyletic group (*A. aethiopicum* group) is recognised by the unusual cell pattern of the inner root cortex. However, investigations are needed to compare root characters with other characters.

INTRODUCTION

The Aspleniaceae is of critical interest in ferns as an advanced cosmopolitan group that includes more than 700 species. These shows great variability in morphological characters and ecological specializations as epiphytes, epipetrics and others. The classification of Aspleniaceae has been discussed in recent literature and the accepted number of genera varies from only one (Kramer & Viane 1990) to 17 (Pichi Sermolli 1977, Tryon 1982). Some older concepts of genera such as *Ceterach*, *Phyllitis* and others are no longer recognised because of the occurrence of hybrids (Lovis 1973). Furthermore Kramer and Viane (1990) stressed that these groups are wholly unnatural because they are founded on one easily observable character of little taxonomic weight. Investigations are needed that deal with large numbers of species as well as a wide variety of characters such as spores, stomata, etc. (Viane 1977, Viane 1988, Saiki et al. 1989). Analysis based on large data sets may clarify the phylogeny of this group and may result in a basis for segregation of apparent parallelism (Holttum 1974, Puttock & Quinn 1980). An example is the delimitation of *Hymenoasplenium* that is supported through various morphological characters and rbcL-gene sequences (Murakami & Moran 1993, Murakami 1995).

MATERIAL & METHODS

Root samples were collected from living plants in botanical gardens (Kaiserslautern, Munchen, Tubingen and Zurich) and during field trips in Central Europe, Malaysia and Ecuador. Freshly sampled roots fixed in 70% ethanol and their vouchers are deposited in the Herbarium of the University of Zurich (Z). However, most of the roots investigated come from the herbaria of the University of Zurich (Z, ZT) and the Natural History Museum London (BM). Dried roots were preserved in 10% tioventin solution for one to three days. Longitudinal and transverse sections were produced with a freezing microtome and examined by optical microscopy using polarized light and various dyes, including FeCl, KJJ, Phloroglucin-HCl, Ruthenium red, Sudan black, Sudan IV, Toluidin blue. Drawings were produced with a camera lucida.

The roots of c.140 species have been studied including members of *Hymenoasplenium* and various satellite genera such as *Antigramma*, *Ceterach*, Diellia, Diplora, *Loxoscaphe*, *Pleurosorus* and *Schaffneria*. The collections represent the broad systematic relations as well as different ecological adaptations.

RESULTS

The roots of Aspleniaceae have a similar construction to other advanced ferns (Schneider 1996). From a taxonomic view point cross-sections illustrate all characters well and longitudinal sections do not provide additional information. The outermost limit of the root is the one cell layer thick rhizodermis which usually possesses a large number of root hairs. The adjacent cortex consists two regions, an outer cortex with thin walled cells and an inner cortex with very thick walled cells. The central cylinder of the root is bounded by the one cell layer thick, secondary endodermis, within which pericycle comprises one or rarely two layers of parenchymatous cells. The metaxylem occupies the centre and the two protoxylem poles with three to four tracheids are located in an exarch position opposite each other. The number of tracheids (4 -16) in the metaxylem correlates with the size of the plant, whereas the structure of the cortex shows a systematically relevant diversity.

Two root types are discriminated, one with five subtypes and eight varieties, the second with one variety. The root types differ in the number of cell layers and the cell types mainly in the inner root cortex. The outer cortex is always parenchymatous and only the number of cell layers varies between species. The following types are distinguished.

Root type 1 (asplenium-type) is marked by presence of typical sclereid-like cells. These cells, first described by Rumpf (1904) for *Asplenium scolopendrium* L. and *A. trichomanes* L., have an extremely thick inner cell wall whereas the outer one is more or less thin. They are pentagonal in shape in transverse sections and the cell walls have a yellow to red brown (rarely dark brown) colour caused by impregnation with tannins and other phenolic components. In longitudinal sections the cells have a typical trapezoid shape. In primitive members (*A. scolopendrium*) the cells have a length of 0.6 - 0.9 mm, whilst in more derived species (*A. trichomanes*) they are shorter (0.3 - 0.4 mm). These cells are named asplenium-sclereids. Subtypes 1.1 to 1.3 have different numbers of cell layers of the inner cortex, whereas in the subtype 1.1 the inner cortex consists of more than 3 cell layers of asplenium-sclereids in which all cells have the same size in transverse section. Subtype 1.3 has only one cell layer. In the subtype 1.2 the inner cortex is composed of more than one cell layer but the cells of the innermost cell layer are larger in size in transverse section than those of the rest of the inner cortex. Transitions are found between1.1 and 1.2 and between 1.2 and 1.3. The differences of subtypes result mostly from differences in cell divisions of the initial cells during root development. Initial cells of the inner cortex make only anticlinal divisions in subtype 1.3 while these of 1.2 and 1.1 divide in anti- and periclinal directions. Therefore it is no surprise that young plants sometimes show roots of subtype 1.3 whereas the adult plants possess roots of 1.1. In contrast to subtypes 1.1 to 1.3 the innermost cell layer in subtype 1.4 always consists of six cells whereas this layer in 1.1 to 1.3 consists of ten or more cells. This reduction is caused by a omission of cell divisions in the innermost cell layer. In some species (1.4.b) the inner cell wall is not as thickened as that in 1.4.a and therefore a larger lumen exists. The remaining cortex consists of none to three further layers of normal asplenium sclereids and three to four parenchymatous outer cell layers. Transitions are missing between subtype 1.4 and the other types. A further interesting construction is seen in the root of *A.alatum* Willd. (subtype 1.5) which possesses the same cell composition in the inner cortex as subtype 1.1, but the inner walls have a relatively weak wall thickening.

A further structure of the inner cortex is the existence of passage cells. These cells have a thinner inner cell wall and a larger number of pits in the walls compared with other of the inner cortex. They are located on the protoxylem poles. In some species the cells of the outer cortex have spiral wall thickenings whereas normally they have thin walls. Characters of widespread occurrence are starch grains and tannin vacuoles. Both have little taxonomic weight because they do not show a constant distribution.

Type 2 (hymenoasplenium-type) do not possess asplenium-sclereids and include all species of *Hymenoasplenium*. The inner cortex of these roots shows only a few cell layers and the cells

have more or less thickened walls. However, in contrast to *Asplenium*, all walls of one cell develop the same thickness. The species of *Hymenoasplenium* vary in the structure of the inner cortex; this may have different numbers of cell layers, various numbers of cells in each layer and, in particular, different thickness of the cell walls. The hymenoasplenium-type is only a variant of the dennstaedtia-type that is found in roots of most genera of advanced fern families (Schneider 1996).

A. Key to the Root cortex types

Roots are classified in a hierarchical system with three steps; type (1 and 2), three subtypes (1.1, 1.2, etc.), varieties (1.1.p, 1.1.ps, etc.).

1. **Asplenium-type:** The inner cortex consists asplenium-sclereids, while the outer one is parenchymatous.
   - 1.1. **Marinum-type**: The inner cortex consists more than one cell layer of asplenium-sclereids. The outer cortex consists of more than one cell layer of thin walled cells.
   - 1.1.p: The inner cortex possess passage cells in the inner cortex:
   - 1.1.s: The outer cortex possess cells with spiral wall thickenings in the outer cortex.
   - 1.1.ps: Both characters (spiral wall thickenings and passage cells) are combined.
   - 1.2. **Adiantum-nigrum-type**: The root cortex has the same structure as in the marinum-type but cells of the innermost cell layer are much larger in size than the remaining inner cortical cells.
   - 1.2.p & 1.2.s: Consist of the combinations of this cortex type with passage cells or spiral wall thickenings.
   - 1.3. **Ceterach-type:** The inner cortex has only one or very rarely two cell layers of asplenium-sclereids. The number of sclereids is ten or more in the layer. The outer cortex has two or more layers of thin walled cells.
   - 1.3.p & 1.3.s: Consist of the combinations of this cortex type with passage cells or spiral wall thickenings.
   - 1.4.a **Aethiopicum-type**: This type is distinguished from the first three types bythe innermost layer of the inner cortex. This layer consists only of six cells, whereas this layer in all other subtypes has ten or more cells. The inner cortex is composed of one dominant innermost layer of six asplenium-sclereids with a large size in cross-sections and none to three more layers of asplenium-sclereids with more than six cells. The outer cortex has three or more layers of thin walled cells.
   - 1.4.b **Flabelliforme-type**: Very simliar to 1.4.a, but the cells of the inner cortex show a larger lumen, because the inner cell wall is less thickened.
   - 1.5. **Alatum-type**: The inner cortex consists of one to three layers of cells with thickened inner walls and thin outer ones, but the thickness of the inner wall is distinctly thinner than other asplenium-sclereids.
2. **Hymenoasplenium-type**: The inner cortex is composed of a different number of cells with more or less thickened walls. In contrast to type 1 the inner and the outer walls show the same thickness. The mostly thick outer cortex has a different number of parenchymatous cell layers.
   - 2.p: Roots with the combination of this inner cortex with passage cells.

B. Occurrences of root types in the investigated species of Aspleniaceae

1. **Marinum type:** *A. anisophyllum* Kunze, *A. annetii* (Jeanp.) Alston, *A. argentinum* Hieron., *A. atroviride* Schelpe, *A. bullatum* Wall., *A. fontanum* (L.) Bernh., *A. marinum* L., *A.*

myriophyllum (Sw.) C.Presl, *A. pteropus* Kaulf.

1.1.p: *A. abscissum* Willd., *A. abyssinicum* Fèe, *A. achilleifolium* (Lam.) C.Chr., *A. acrobryum* Christ, *A. brasiliense* Sw., *A. douglasii* Hook., *A. d'urivillei* Mett., A. *enatum* Brack., *A. erectum* Bory, *A. fissum* Kit., *A. hemionitis* L., *A. lunulatum* Sw., *A. nidus* L., *A. scolopendrium* L., *A. thunbergii* Kunze, *A. tocaraimense* Rosenst., A. *tucunanese* Hieron., *A. ulbrechtii* Rosenst.

1.1.s: *A. amboinense* Willd., *A. angustum* Sw., *A. gemmiferum* Schrad., *A. gibberosum* (G.Forst.) Mett., *A. obtusatum* G.Forst.

1.1.ps: *A. diplaziosorum* Hieron., *A. elliotii* C.H.Wright

1.2. **Adiantum-nigrum type**: *A. adiantum-nigrum* L., *A. adulterinum* Milde, *A. boltonii* Hook., *A. bugoiense* Hieron., *A. feei* Kunze, *A. foreziense* Legrand, *A. formosum* Willd., *A. lucidum* G.Forst., *A. monanthes* L., *A. mucronatum* C.Presl, *A. normale* D.Don, *A. obovatum* Viv., *A. radicans* L., *A. rutaceum* (Willd.) Mett., *A. ruta-muraria* L., *A. sagittatum* (DC.) Bange, *A. sessilifolium* Desv., *A. tenuifolium* D.Don., *A. tripteropus* Nakai, *A. yunnanense* Franch., *Diellia erecta* Brack.

1.2.p: *A. obovatum* sensu *lanceolatum* P.Silva

1.2.s: *A. africanum* Desv., A. longicauda Hook.

1.3. **Ceterach type**: *A. aichstonii* Fraser-Jenk. & Reichst., *A. aureum* Cav., *A. auriculatum* (Thunb.) Kuhn, *A. auritum* Sw., *A. austrobrasiliense* (Christ) Maxon, *A.* barteri Hook., *A. billettii* Christ, *A. bipartitum* Bory, *A. bipinnatifidum* Baker, *A. ceterach* L., *A. cuspidatum* Lam., *A. delavayi* (Franch.) Copel., *A. divergens* Mett., A. dognyense Rosenst., A. ensiforme Wall., A. exiguum Bedd., Diellia falcata Brack., *A. formosae* Christ, *A. hapalophyllum* Rosenst., *A. heterochroun* Kunze, *A. negripes* (Fèe) Hook., *A. pulchellum* Raddi, *A. quitense* Hook., *A. repens* Hook., *A. rhizophyllum* L., *A. septentrionale* (L.) Hoffm., *A. subglandulosum* (Hook. & Grev.) Salvo, Prada, & Diez, *A. supposition* Hieron., *A. tenerum* G.Forst., *A. tenuicaule* Hayata, *A. trichomanes* L., *A. trilobum* Cav., *A. triphyllum* C.Presl, *A. tuerckheimii* Maxon, *A. variablilis* Hook., *A. varians* Wall., *A. vieillardii* Mett., *A. vittaeforme* Cav., *A. vulcanicum* Blume, *A. wrightii* Eaton

1.3.s: *A. daucifolium* Lam., *A. dregeanum* Kunze, *A. sandersonii* Hook., *A. scalare* Rosenst., *A. theciferum* (Humb.,Bonpl. et Kunth) Mett., *A. viviparoides* Kuhn

1.4.a **Aethiopicum type**: *A. actinopteroides* A.Peter, *A. aethiopicum* (Burm.f.) Bech., *A. affine* Sw., *A. attenuatum* R.Br., *A. blastophorum* Hieron., *A. brassei* C.Chr., *A. caudatum* G.Forst., *A. dissectum* Sw., *A. elmeri* Christ, *A. exhaustum* (Christ) Alston, *A. finlaysonianum* Wall., *A. linckii* Kuhn, *A. lobulatum* Sw., *A. macrophyllum* Sw., *A. praemorsum* Sw., *A. schizocarpum* (Copel.) Copel., *A. serra* Langsd. & Fisch., *A. uhligii* Hieron., *A. yoshinageum* Makino, *A. zamiaefolium* Willd.

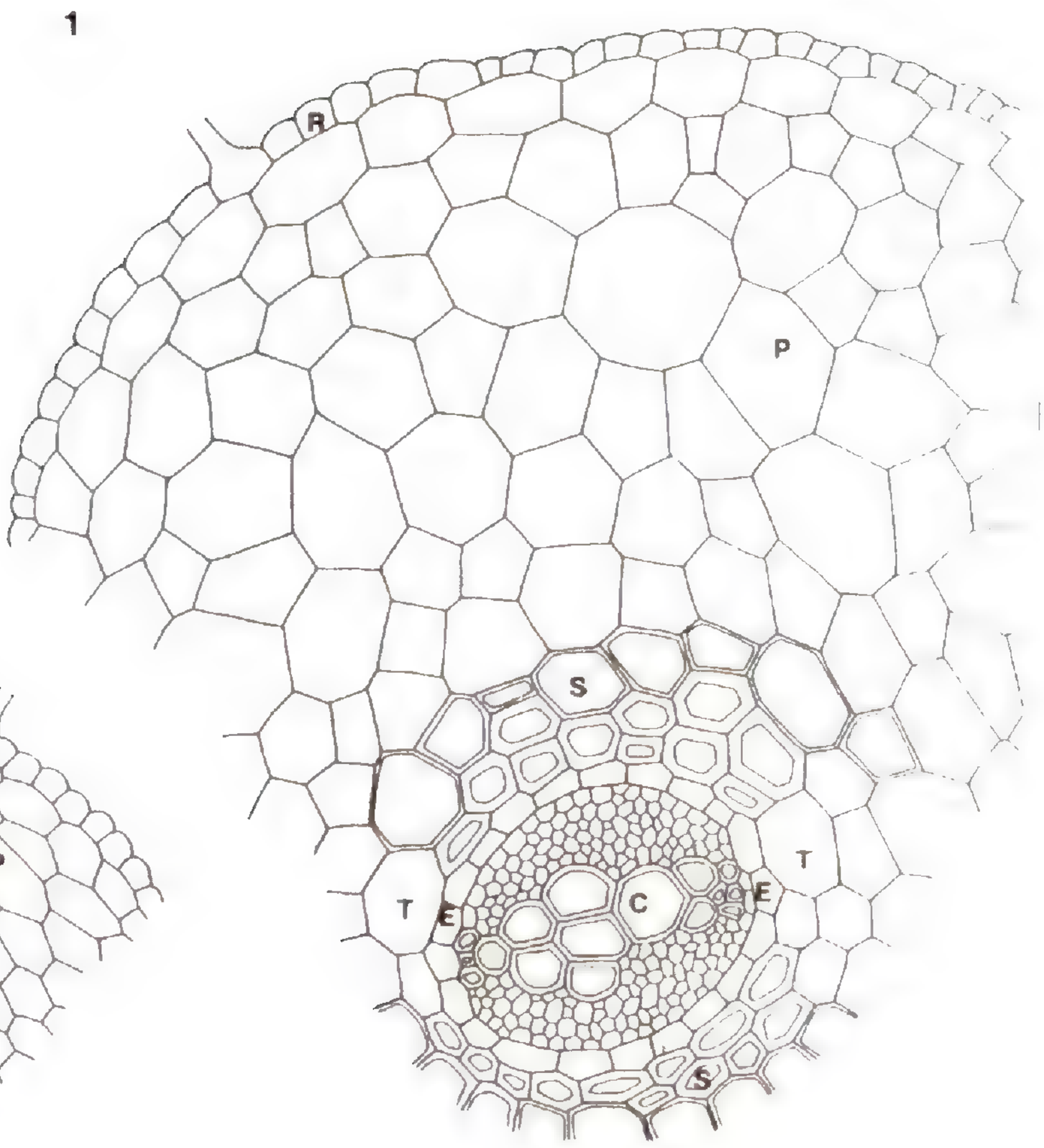
1.4.b **Flabellifolium-type**: *A. flabellifolium* Kunze, *A. volkensii* Hieron., *A. willfordii* Mett.

1.5. **Alatum Type**: 1.5.p.: *A. alatum* Willd.

2. **Hymenoasplenium type**: *A.. cheilosorum* Kunze, *A. hoffmanii* Hieron., *A. laetum* Sw., *A. obliquissimum* Hayata, *A. riparium* Liebm., *A. triquetrum* N.Murak. & R.C.Moran, *A. unilaterale* Lam.

2.p: *H. delitescens* (Maxon) L.D.Gomez, *H. excisum* C.Presl

Remarks: The *Asplenium* synonyms are used for *Hymenoasplenium* because only few recombinations are in existence. However, all examined specimens of *Hymenoasplenium* have roots of the hymenoasplenium-type. The two species of *Diellia* are given as these combinations, because none are available for *Asplenium*.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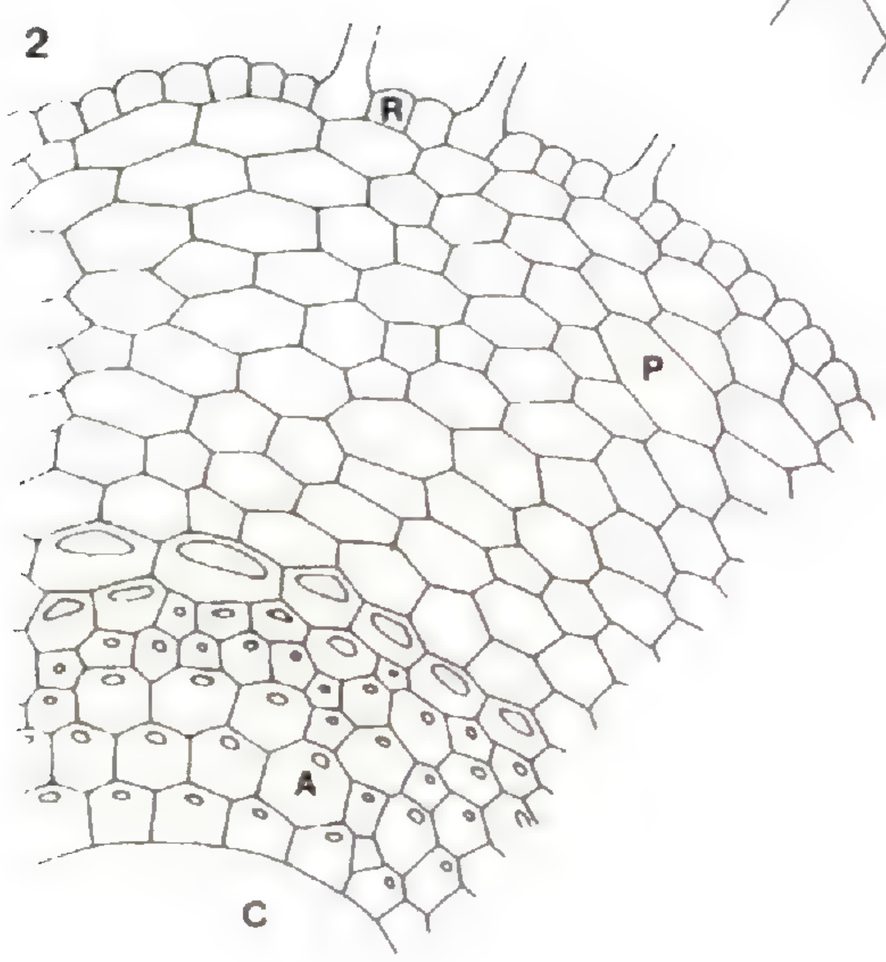
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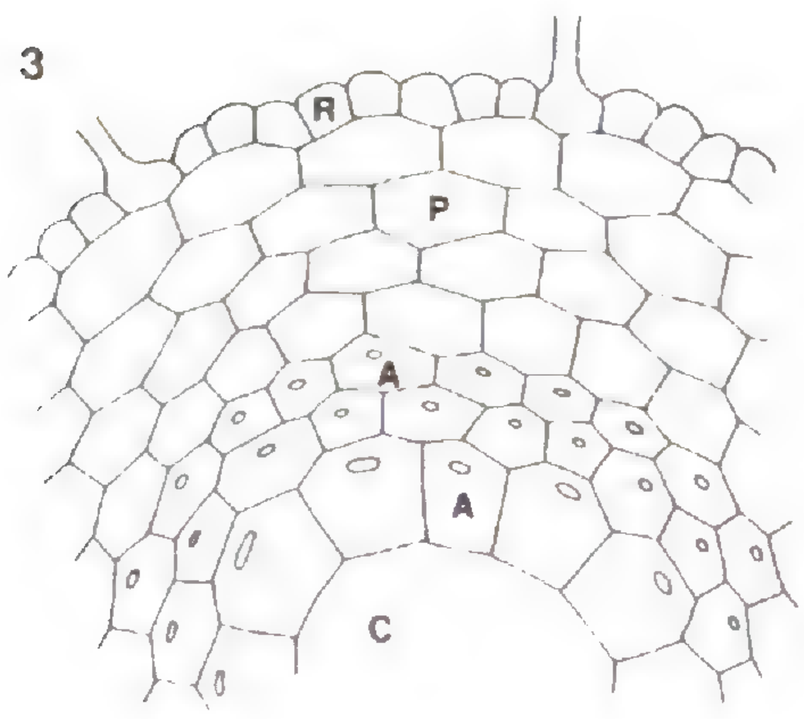
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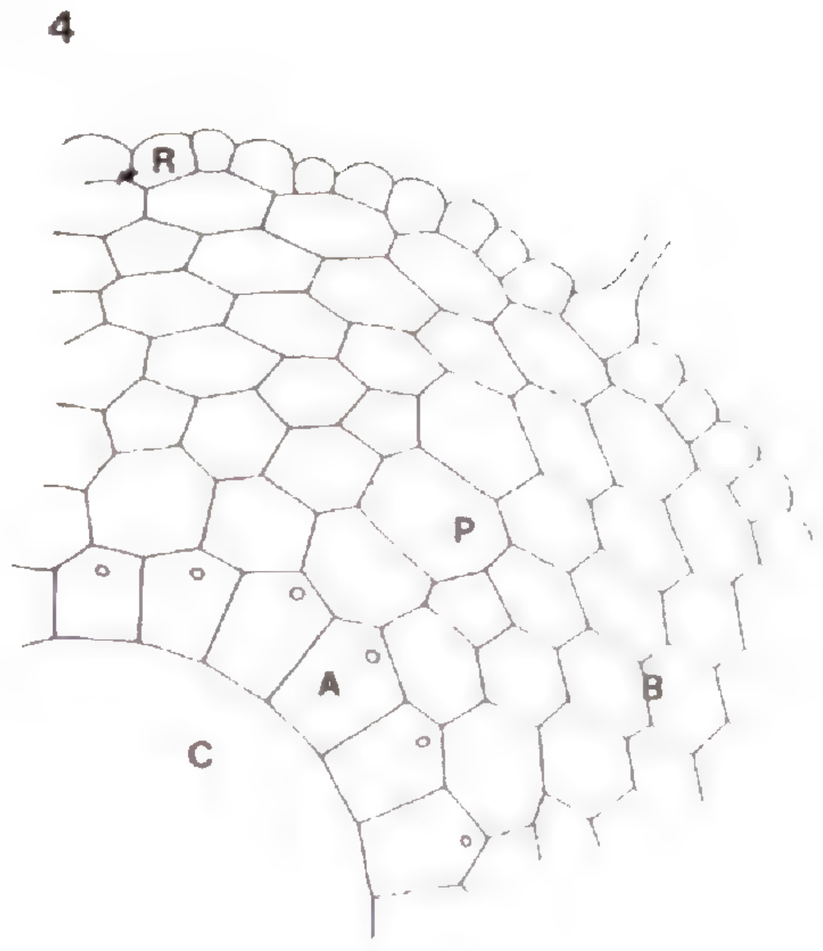
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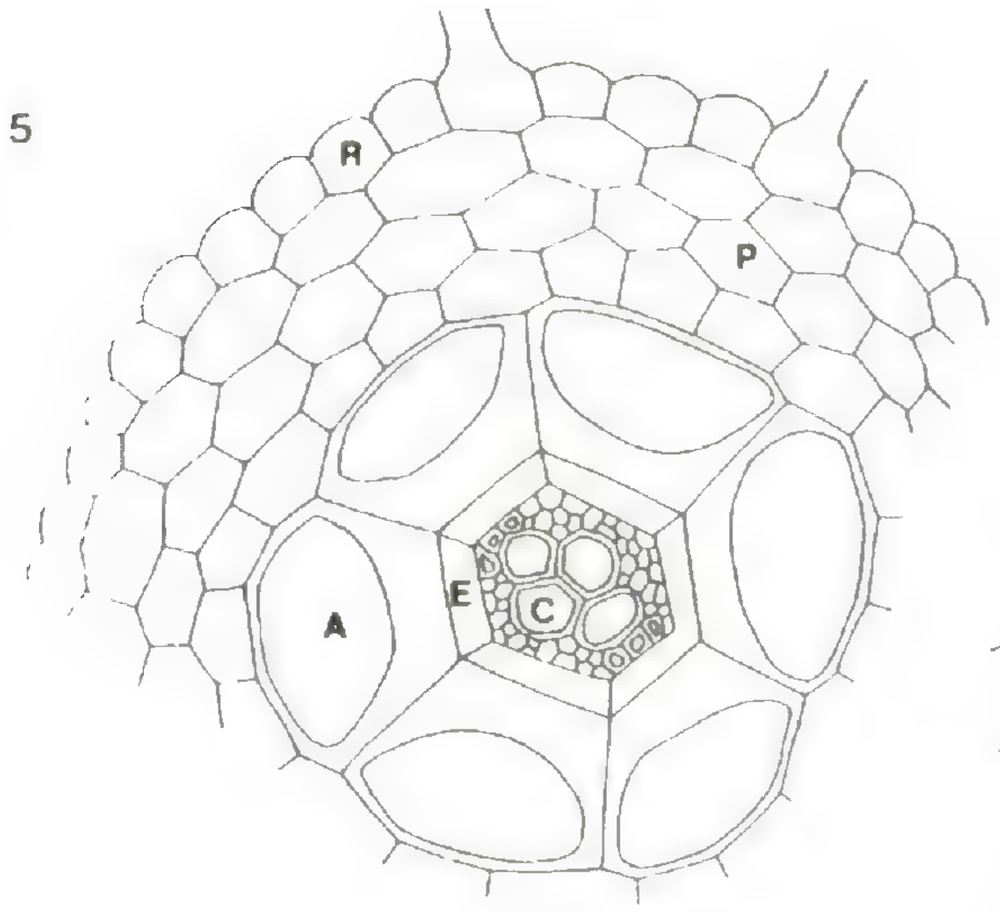
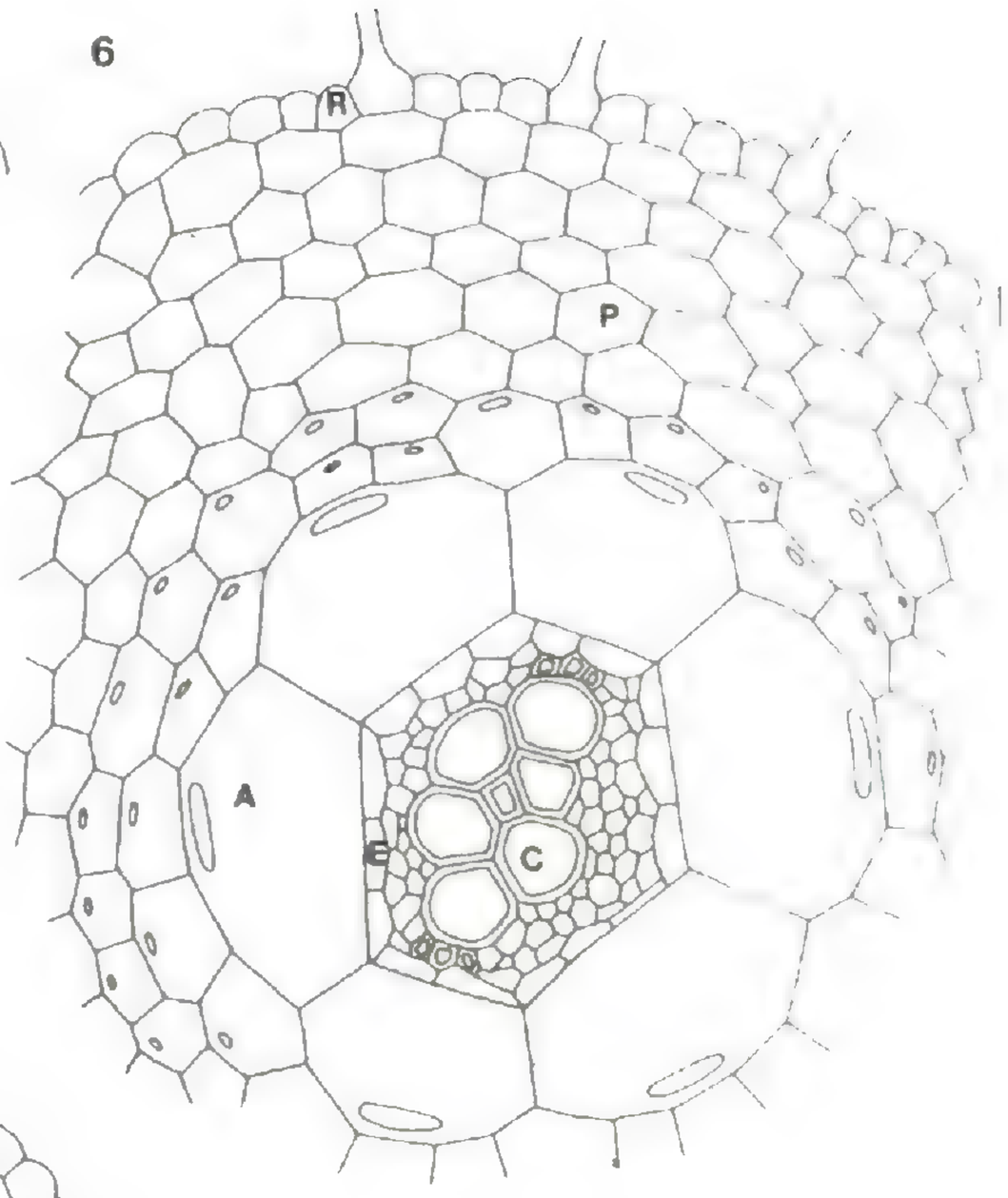
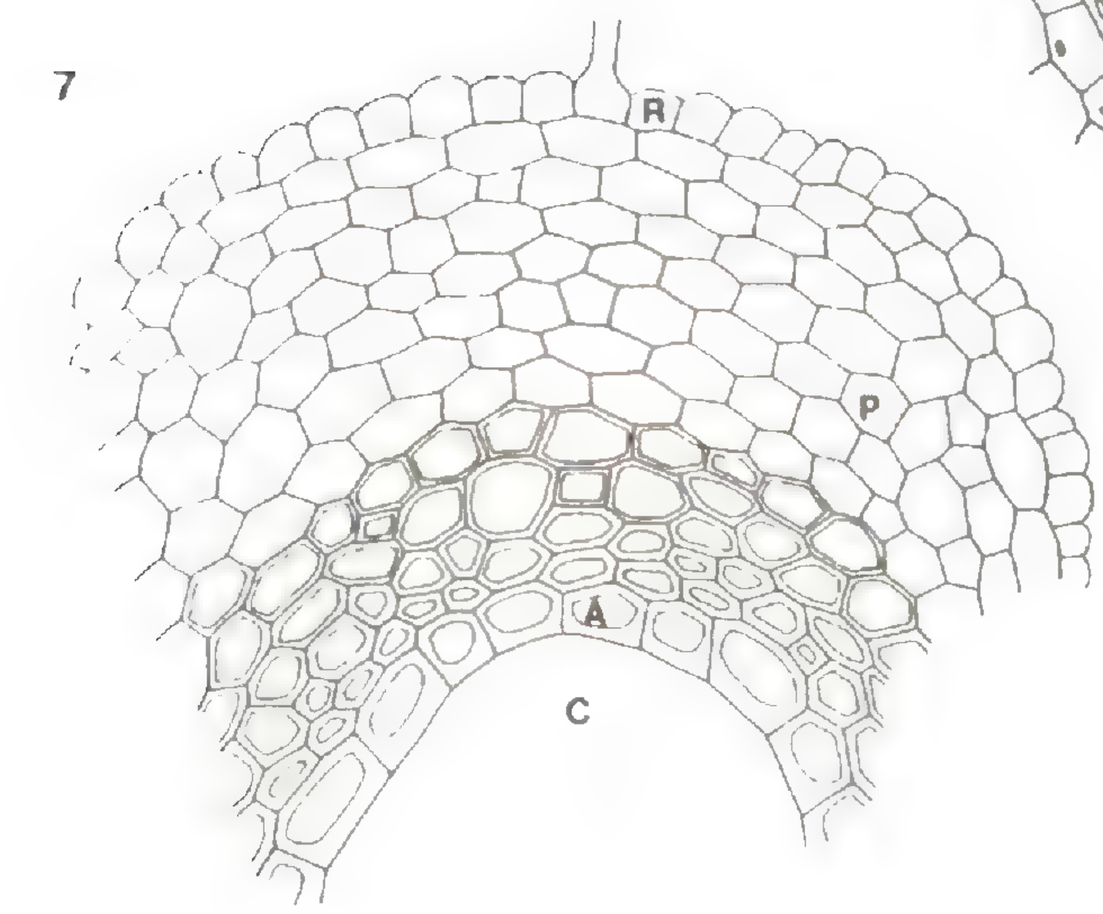






Figures 1-7. Cross-sections of the root cortex. Fig. 1. *Asplenium delitescens* (Maxon) L.D.Gomez (*Hymenoaplenium*). Fig. 2. *Aplenium marinum* L. Fig. 3. *Asplenium adulterinum* Milde. Fig. 4. *Aplenium aureum* Cav. Fig. 5. *Asplenium willfordii* Mett. Fig. 6. *Asplenium aethiopicum* (Burm.f.). Fig. 7. *Asplenium alatum* Willd.
Bar lines 82µm ; A, asplenium-sclereids; C, central-cylinder; E, endodermis; P, parenchymatous cells; R, rhizodermis; S, sclerenchymatous cells; T, passage cell

Discussion

Two genera are delimited in the Aspleniaceae based on the character of asplenium-sclereids. This cell type represents a unique character of the genus *Asplenium* and distinguishes this genus from *Hymenoasplenium* and all other advanced ferns. Other proposed genera in the family have very similar root anatomy and roots morphology does not provide support for segregation of the following genera - *Antigramma*, *Camptosorus*, *Ceterach*, *Diellia*, *Diplora*, *Loxoscaphe*, *Phyllitis*, *Pleurosorus*, and *Sinephropteris*.

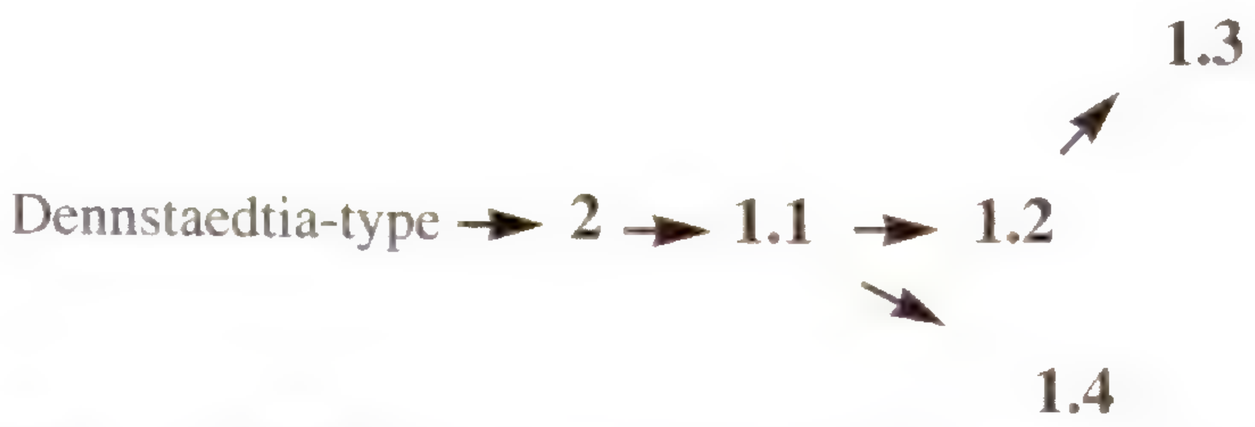
The roots of *Hymenoasplenium* show a primitive (or plesiomorph) character state in comparison with roots of other advanced fern families because the occurrence of sclerenchymatous inner cortex formed by cells with equal thick cell walls characterized

Dryopteridaceae, larger parts of Blechnaceae and the primitive genera of Woodsiaceae (Schneider 1996).

Primitive species of *Asplenium* such as *A. scolopendrium* (Murakami 1995) possess an inner root cortex with many cell layers of asplenium-sclereids and a thick parenchymatous outer cortex. Advanced species show a reduction of the number of cortical cell layers. Especially the numbers of cell layer of the inner cortex are reduced to one in more advanced species. The lower number of cell layers correlates with modification of asplenium-sclereids, increase of cell size in transverse sections and a decrease of cell length. In an intermediate state (subtype 1.2) the cells of the innermost cortex layer have a larger size in transverse sections compared with cells of the surrounding inner cortex layers. Roots of this type are described for the satellite genus *Diellia* (Wagner 1953) also found in the *A. trichomanes* group. This similarity supports relationships proposed by Wagner (1953). The subtypes 1.1 to 1.3 present a more or less continuous progression whereas roots of type 1.4 have probably arisen from 1.2 without transitions. The existence of more than one sclerenchymatous cell layer suggests a second progression line from subtype 1.2 to 1.4, parallel to the line 1.1 to 1.2 to 1.3. Roots with the subtype 1.4 have been found in 18 species that include the *A. caudatum* group (Holttum 1966) and the *A. praemorsum* group (Christ 1897). Both may represent parts of a monophyletic section, named as the *A. aethiopicum* group. However, comparisons are needed with other character complexes. Certainly the lower number of cell layers results from reduction in the number of cell divisions during the root ontogeny but, as described by Gifford (1991), the inner cortex originates from a one-cell layer of initial cells. The reduced number of asplenium-sclereids is clearly a neoteny which may evolve more than once. However, it is certainly an evolutionary trend and perhaps the specialised innermost cell layer has independently evolved in subtypes 1.4 and 1.2.

Another interesting root is shown in *A. alatum* which may be reflect either a secondary reduction of the cell wall thickness of the asplenium-sclereids (neoteny) or a primitive character

Evolutionary scheme of root characters of Aspleniaceae



state. A similar reduction of wall thickness found in subtype 1.4.b that is a modification of 1.4.a. The significance of the number of cell layers and the size of their cells needs more examination because they may be correlated with the ploidy level. Similar correlation has been demonstrated for size of stomata (Viane 1988).

Other characters of the cortex such as passage cells and spiral wall thickenings occur in other not closely related ferns and they may result from parallel evolution. Spiral wall thickenings can often be found in epiphytic fern genera and those cells probably have similar functions to similar cells in the velamen of epiphytic Orchidaceae (Schneider 1996). Examples for epiphytic ferns with these cells are Grammitidaceae, Polypodiaceae, and Vittariaceae (proparte) but other epiphytic fern families lack such cells (Davalliaceae). Some typical epiphytic *Asplenium* species (*A. theciferum*) possess spiral wall thickenings while others lack

this character (*A. nidus*). However, some ferns growing on moist rocks (*A. africanum, A. daucifolium*) have these cells in the outer cortex. No other characters of the cortex show such clear correlation with habit. Members of *A. praemorsum* group often grow in dryer conditions, but those of the *A. caudatum* group are mostly epiphytes (Kornas 1979, Burrows 1990, Tryon & Stolze 1993). Thin roots of the type 1.3 are often found in species growing on walls and rocks (Kramer 1984) which may be related to the small root space in those substrates.

The significance of the established root types must be proved byfurther studies in comparison with other character complexes. Only a small proportion of the 700 or more species have been investigated but root characters may be a useful character in studies of the evolutionary position of the family as well as their members.

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FERNS OF THE BLACK SEA REGION OF TURKEY: CHOROLOGICAL AND ECOLOGICAL STUDIES

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Key words: Ferns, chorology, ecology, Black Sea Region, Turkey

ABSTRACT

This study is based on the chorological and ecological investigation of fern species collected from Black Sea regions between 1993-1995 and the observations made in field. In the study area, distribution of 40 fern species belonging to 18 genera has been established. Genera treated are *Osmunda, Cheilanthes, Adiantum, Pteris, Cryptogramma, Polypodium, Pteridium, Oreopteris, Phegopteris, Asplenium, Matteucia, Athyrium, Gymnocarpium, Cystopteris, Woodsia, Polystichum, Dryopteris, Blechnum.* Ecological properties of these species have been established based on rock and soil samples collected in the area, as well as investigation of the growth environment.

INTRODUCTION

Fern specimens collected during floristic studies in this area have been reported in the literature (Davis 1965, 1988; Demiriz et al. 1969; Coskun 1978; Kılınç and Özen 1988; Kutbay et al 1995; Özen and Kılınç 1995; Kaynak et al 1996). However, no thorough chorological and ecological investigation of the fern species found in this area has been reported, even though the Black Sea region is very rich in several of the species. The purpose of this investigation was to establish the ecological properties and distribution of fern species in this region on the basis of their growth environment.

The area studied is the northern part of Turkey and includes squares A3, A4, A5, A6, A7, A8 and A9 of the system established in the "Flora of Turkey " by P. H. Davis. In this region an oceanic climate is dominant which is characterised by the absence of dry seasons. However, in some areas near the shore and in the interior region a Mediterranean climate is also encountered. Accordingly, in Abana, Gerze, Trabzon, Sinop, Ayancık, Alaçam and Samsun, a Western Mediterranean rainfall pattern is observed with an annual rainfall of 680 to 1050 mm, and a dry summer season which lasts between one to four months. In the regions of Karabuk, Safranbolu, Tasova, Erbaa, Niksar and Resadiye, an Eastern Mediterranean rainfall pattern is dominant, as characterised by a dry summer season longer than three months and average annual rain fall between 304 and 475 mm. In the region known as the pre-Black Sea, which includes Bolu, Devrek, Kastamonu, Gümüshane, Taskopru and Ladik, the annual rainfall is between 360 and 850 mm. On the coastal areas of Black Sea region, an oceanic climate is dominant, characterised by the absence of a dry summer season. Annual rainfall in this area is consequently quite high. The amount of annual rainfall increases progressively towards the eastern regions, being between 925 and 1200 mm in the west, while reaching up to 2400 mm in the eastern regions. Rainy seasons are autumn and winter. The dominant vegetation type in the region is forest. At lower altitudes the forest type is deciduous, including *Fagus orientalis, Castanea sativa, Carpinus orientalis, C. betulus, Acer campestre, A. trautvetteri, Alnus glutinosa, A. barbata, Rhododendron ponticum*, and *R. flavum* , while at higher altitudes the forest type changes to conifers including species like *Abies nordmanniana, A. bornmuelleriana, Pinus sylvestris* and *Picea orientalis*. On the coastal areas of the Black Sea region the dominant vegetation type is dense maquis formed by *Pistacia atlantica, P. palaestina, Arbutus andrachne, A. unedo, Rhamnus elatermus, Myrtus communis, Quercus ilex, Paliurus australis* and *Phillyrea latifolia.*

Table 1: Numbers of taxa and genera of the fern families represented in Black Sea region.

FAMILY	GENERA	TAXA
Osmundaceae	1	1
Adiantaceae	3	3
Pteridaceae	1	1
Polypodiaceae	1	3
Dennstaedtiaceae	1	1
Thelypteridaceae	2	2
Aspleniaceae	1	11
Woodsiaceae	5	6
Dryopteridaceae	2	11
Blechnaceae	1	1
TOTAL	18	40

MATERIALS AND METHODS

Fern specimens included in this study were collected from western (Sakarya, Bolu, Zonguldak, Bartın), central (Kastamonu, Sinop, Çorum, Amasya, Samsun) and eastern (Ordu, Giresun, Trabzon, Rize, Artvin) Black Sea Regions between 1993 and 1995. The authors have visited 123 localities (between 0-2600 m. altitudes). This material consist of 450 specimens deposited to be found in the Herbarium of the Faculty of Science and Art, University of Uludağ (BULU). Identification of specimens was based on Flora of Turkey (Davis 1965) and other related studies (Coskun 1978, Kaynak et al. in press).

Ecological properties and growth environment of specimens collected from the area were determined on the basis of soil samples taken from the growth environment, along with rock samples, if possible, and meteorological data. Data on pH and $CaCO_3$ content of soil samples collected are summarised in Table 2. $CaCO_3$ content was determined by Scheibler calcimeter and pH was measured using Ingolds pH electrodes. Identification of rock samples was carried out by Dumlupınar University Geology Department. Data for the types of rocks on which fern species were collected and average annual rainfall in the fern growth areas are summarised in Table 3.

OSMUNDACEAE

Osmunda regalis L.

A 8: ARTVIN: Arhavi; around Dikyamaç village, under mixed forest of *Fagus, Carpinus, Alnus* with mainly *Corylus, Rhododendron* shrub layer, 450 m., 27.7.1995, O.Benlioğlu, BULU 9418. - Arhavi; Çifteköprü, 200 m., 27.7.1995, O.Benlioğlu, BULU 9408.

ADIANTACEAE

Cryptogramma crispa (L.) R.Br. ex Hooker

A 8: ARTVIN: Arhavi; between Dikyamaç village and Yayla road, rocky places, 600m.,27.7.1995, N. Simsek, BULU 9407.

Cheilanthes marantae (L.) Domin subsp. **marantae**

A 5: KASTAMONU: Tosya; between Tosya and Çiftlik, rocky places, 1120 m., 21.8.1994, N. Simsek, BULU 8941B.

A 8: RIZE: Ispir; screes of Gültepe village, on rocks, 1200 m., 15.7.1995, N. Simsek, BULU 9524 B.

Adiantum capillus-veneris L.

A 4: KASTAMONU: Abana, around Yakaören, rocks, 200 m., 26.8.1994, G.Kaynak et

G.Tarımcılar, BULU 9057. - between Cide and Kurucasile, damp rocks in forest, 1050 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9130. - Amasra; Amasra to Bartın, 3 km., on damp rocks, 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9141.

A 5: SINOP: between Kargı and Osmancık, before the province border of Çorum, on damp rocks, 315 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 8977.

A 7: GIRESUN: Dereli, rocky places, 140 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7758 A. - Kesap to Espiye, 10 km., edge of water in *Fagus* and *Castanea* forest, 30 m., 25.7.1995, O.Benlioğlu, BULU 9402. - TRABZON: Trabzon 19 km., to Maçka, roadside and on wet rocks, 500 m.,26.8.1993, G.Kaynak , G.Tarımcılar, BULU 7806 A.

A 8: RIZE: Çayeli; 7,5 km. to Çayeli, in the vicinities of Sögütlü village, on damp and shady rocks, 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7857 B. - ARTVIN: 1,5 km to Ardanuç crossroad, around Düzlüce, on wet rocks, 240 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7885. - Ardanuç; between Ardanuç and Kutul, Yalnızçam mountain, on rocks, 1230 m., 29.81993, G.Kaynak and G.Tarımcılar, BULU 789.

PTERIDACEAE

Pteris cretica L.

A 6: ORDU: Gülyalı; Kestane village, under *Corylus* plantation, 200 m., 29.7.1995, O.Benlioğlu, BULU 9401.

A 7: GIRESUN: Kesap- Espiye, 10 km., under *Fagus* and *Castanea* forest, 30 m., 25.7.1995, O.Benlioğlu, BULU 9397.

A 8: RIZE: Ikizdere; crossroad to Kalkandere, underwood, 350 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7822 B. - Çamlıhemsin; Palovit valley, roadside, 800-850 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7880 B. - Hopa; Sarp, roadside and edge of forest, 0 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7981 A. - ARTVIN: Arhavi; around Dikyamaç village, 420-450 m., 27.7.1995, O.Benlioğlu, BULU 7873.

POLYPODIACEAE

Polypodium vulgare L.

A 3: BOLU: Yedigöller, on damp rocks in forest, 310 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9174. - in the vicinities of Asalar, on rocks, 140 m., 29.9.1995, G.Tarımcılar, BULU 9390. - ZONGULDAK: Kızılcapınar, around Sinitli village, under *Quercus* bushes, 80 m., 30.9.1995, G.Tarımcılar, BULU 9398.

A 4: KASTAMONU: between Inebolu and Küre, 11 km. to Ersizler, rocky places in mixed forest (*Fagus, Carpinus, Castanea*) , 800 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9063. - Ağlı; between Ağlı and Senpazar, in the vicinities of Sada village, under *Abies* forest, 920 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9077. - around Valay village, under *Fagus* forest, 640 m., 29.8.1994, G.Kaynak and G.Tarımcılar, BULU 9091.

A 5: SINOP: Ayancık to Yenikonak, 6 km., slopes of Çangal mountain, under mixed forest (*Platanus, Acer, Ulmus, Quercus*), 330 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9024 A.

A 6: ORDU: Çamas; around Güngören, roadside, 700 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 9076. - around Gürgentepe, roadside, 1180 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7748.

A 7: GIRESUN: Görele; 7 km. W of Görele, roadside, on rocks, 60 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7800 B.

A 8: RIZE: Ikizdere; around Çamlık village, under forest, 1300 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7839 A. - Çamlıhemsin; 2 km. to Köprübası, on rocks, 130 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7858 B. - ARTVIN: Sarp; 5 km. from Kemalpasa on the way to Sarp, roadside, steep rocks, 0 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7917.

P. interjectum Shivas

A 3: BOLU: Devrek; on the way to Yedigöller, 25 km to Yedigöller National Park, rocky slopes, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9156.

A 4: KASTAMONU: between Senpazar and Cide, under mixed forest, 960 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9108.

A 7: TRABZON: Of; between Of and Hayrat, rocks, 200 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7809 A.

A 8: TRABZON: Çaykara, streamside, wet rocks, 230 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7812. - above Atabey, on rocks fissures in *Picea* forest, 660 m., 28.7.1995, O.Benlioğlu, BULU 7871.- RIZE: Çayeli; 7,5 km., to Çayeli, in the vicinities of Söğütlü village, rocks, 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7844. - ARTVIN: Arhavi; between Arhavi and Dikyamaç village, on walls and stones, 200 m., 27.7.1995, O.Benlioğlu, BULU 7767.

P. cambricum L.

A 6: ORDU: in the vicinities of Uzunali, on stone walls, 875 m., 24.8.1995, G.Kaynak and G.Tarımcılar, BULU 7786.

A 7: TRABZON: Maçka; around Zigana pass, on rock fissures in *P. slyvestris* forest, 2000 m., 26.7.1995, O.Benlioğlu, BULU 7839. - GIRESUN: Dereli; on the way to Kümbet yayla, around Çamurköy, streamside, on tree, 870 m., 25.8.1995, G.Kaynak and G.Tarımcılar, BULU 7758 B.

DENNSTAEDTIACEAE

Pteridium aquilinum (L.) Kuhn

A 3: BOLU: Devrek; on the way to Yedigöller, 25 km. to Yedigöller National Park, roadside, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9157. - SAKARYA: between Karasu and Akçakoca, streamside, under *Corylus* plantation, 70 m., 29.9.1995, G.Tarımcılar, BULU 9385. - Kocaali to Ortaköy, 5 km., roadside, 180 m., 29.9.1995, G.Tarımcılar, BULU 9386. - BOLU: Asalar, roadside, 140 m., 29.9.1995, G.Tarımcılar, BULU 9388. - Akçakoca, under *Corylus* plantation, 60 m., 30.9.1995, G.Tarımcılar, BULU 9392. - in the vicinities of Abant lake, edge of forest, 1350 m., 1.10.1995, G.Tarımcılar, BULU 9424.- ZONGULDAK: Devrek; between Ereğli and Devrek, around Delihakkı, under bushes, 20 m., 30.9.1995, G.Tarımcılar, BULU 9394. - around Yazıcılar, under *Quercus* oak, 30.9.1995, G.Tarımcılar, BULU 9395. - near Buldan bridge, 20 m., 30.9.1995, G.Tarımcılar, BULU 9409.

A 4: ZONGULDAK: Çaycuma; 1 km to Hisarönü, maquis, 14 m., 30.9.1995, G.Tarımcılar, BULU 9411. - 8 km.th.from Zonguldak on the way to Beycuma, streambed, 220 m., 1.10.1995, G.Tarımcılar, BULU 9416. - BOLU: between Mengen and Gökçesu, *Rubus* bushes, 576 m., 1.10.1995. - KASTAMONU: Araç; 12 km.th. from Araç on the way to Daday, mixed forest of *P. nigra, Quercus, Ulmus*, 1040 m., 22.8.1994, G.Kaynak and G.Tarımcılar, BULU 8908. - Daday; between Daday and Azdavay, under *Abies* forest, 1400 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8921. - Akkaya; 9 km.th. from Akkaya on the way to Tosya, streamside, 880 m., 23.8.1994, G.Kaynak and G.Tarımcılar, BULU 8937. - Inebolu; road to Küre, roadside, 440 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9061.- Ağlı; between Ağlı and Senpazar, around Hıdırlar village, under *Fagus* forest, 790 m., 29.8.1994, G.Kaynak and G.Tarımcılar, BULU 9082. - Senpazar; between Senpazar and Cide, 20 km th., to Cide, edge of forest, 890 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9113.

A 5: AMASYA: 10 km. th. from Amasya on the way to Tasova, roadside, 385 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 8991. - SAMSUN: Bafra; between Alaçam and Çamaltı, rocks, roadside, 1000 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9008 A. - SINOP: Ayancık; Gürgendibi, edge of forest, 70 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9014. - Ayancık; between Ayancık and Gökçeağaç, W slopes of Çangal mountain,330 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9026. -

KASTAMONU: Abana; between Çatalzeytin and Abana, mixed forest of *Platanus, Acer, Quercus,* 200 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9055. - between Tosya and Çiftlik road, roadside, 1560 m., 23.8.1994, G.Kaynak and G.Tarımcılar, BULU 8941A.

A 6: ORDU: Çamas; around Güngören, roadside, 700 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 7737. - SAMSUN: Kavak; between Kavak and Kolay, 2 km. to Çakıralan village, roadside, 660 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9004. - Tasova; 13 km. th. from Tasova to Ladik, roadside, 860 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 8999.

A 7: GIRESUN: Dereli; tasocağı location, under Corylus plantation, 90 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7753. - TRABZON: 19 km. to Maçka, roadside, 500 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7805. - Maçka; 9 km. to Değirmendere village, along rivulet and rocky places, 850 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7808.

A 8: RIZE: Çamlık, edge of forest, 1400 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7838. - Çamlıhemsin; roadside, 440 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7867. - ARTVIN: Ardanuç; between Ardanuç and Kutul, Yalnızçam mountain, under *Picea* forest, 1600 m., 29.8.1993, G.Kaynak and G.Tarımcılar,BULU 7892. - Borçka, roadside, 260 m., G.Kaynak and G.Tarımcılar, BULU 7900. - Sarp; 5 km. th. from Kemalpasa on the way to Sarp, roadside, streep rocks, 0 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7920.

A 9: ARTVIN: Ardanuç; between Ardanuç and Savsat, roadside, 1800 m., 30.8.1993, G.Kaynak and G.Tarımcılar, BULU 7895.

THELYPTERIDACEAE

Oreopteris limbosperma (Bellardi ex All.) Holub

A 6: ORDU: Çamas; around Uzunali, roadside, damp slopes, 875 m., 24.8.1995, G.Kaynak and G.Tarımcılar, BULU 7741. - Gürgentepe; 5 km. th., from Gürgentepe to Gürgentepe pass, edge of forest, 1180 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7747.

A 7: GIRESUN: Dereli; between Giresun and Dereli, 8 km. to Çalça, damp rocks, 140 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7759. - on the way to Kümbet yayla; around Yüceköy village, edge of *Picea* forest, 970 m, 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7784. - Bulancak, under mixed forest of *Fagus, Carpinus, Castanea* forest, 30 m., 25.7.1995, O.Benlioğlu, BULU 7742.

A 8: TRABZON: between Çaykara and Bayburt, N slopes of Soğanlı mountain, stony gorge, amongst rocks, 1800 m., 28.7.1995, O.Benlioğlu, BULU 7743.- RIZE: Ardesen; between Ardesen and Çamlıhemsin, 12 km to Çamlıhemsin, edge of mixed forest, 130 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7855. - Çamlıhemsin; Palovit valley, edge of *Picea* forest, 800-850 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7744. - ARTVIN: Borçka; 49 km. th. from Artvin on the way to Borçka, damp rocky slopes and wet soil, 670 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7908.

Phegopteris connectilis (Michx) Watt

A 7: TRABZON: between maçka and Meryemana, under *Fagus, Carpinus, Alnus, Picea,* forest, 1600-1700 m., 26.7.1995, O.Benlioğlu, BULU 7856.

A 8: TRABZON: Çaykara; N slopes of Soganlı mountain, amongst rocks, 1600 m., 28.7.1995, O.Benlioğlu, BULU 7827. - RIZE: Ikizdere; Anzer yayla, under *Picea* forest, 1550-1650 m.,27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7832.

ASPLENIACEAE

Asplenium trichomanes L. subsp. **trichomanes**

A 3: ZONGULDAK: between Ereğli and Devrek, Düzpelit to Armutlucuma, 4 km., under maquis, 270 m., 30.9.1995, G.Tarımcılar, BULU 9405. - BOLU: Devrek; Eğerci, damp rocks, 250 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9152. - Devrek; on the way

toYedigöller, 25 km. to Yedigöller National Park, damp rocks under forest, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9155.

A 4: KASTAMONU: Ağlı; between Ağlı and Senpazar, in the vicinities of Sada village, on rocks in *Abies* forest, 920 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 7918 A. - around Valay village, on damp rocks in *Fagus* forest, 640 m., 29.8.1994, G.Kaynak and G.Tarımcılar, BULU 9078. - Senpazar; between Senpazar and Cide, 20 km. to Cide, on damp rock fissures, 890 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9092. - BARTIN: Kurucasile, on rocks, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9138.

A 5: SINOP: Boyabat, 9 km. to Saraydüzü, around Yeniceköyü, rocks and edge of *Pinus* forest, 320 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 8972. - Ayancık; NW slopes of Çangal mountain, on rocks in mixed forest of *Acer, Ulmus, Quercus, Platanus,* 890 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9033. - ÇORUM: Osmancık; around Eymir village, edge of water, rocks, 420 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 9481. - AMASYA: Amasya, rocks, 470 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 8987. - KASTAMONU: Ilgaz mountain, on rock fissures exposed to the sun in *Abies* forest, 1865 m., 24.7.1995, BULU 9019.

A 6: AMASYA: 10 km. th. from Tasova on the way to Amasya, on rocks, 385 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 8987 A.

A 7: GIRESUN: on the way to Kümbet yayla ;around Çamurköy, streamsides, on rocks, 870 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7762. - around Yüceköy, along rivulet, clayish soil, 900 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7783 B. - Espiye; around Armelet village, N slopes of Armelet mountain, shady rocks in *Alnus,* forest, 370 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7795 B. - TRABZON: Maçka; 9 km. to Değirmendere, along rivulet, rocky places, 850 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7809.

A 8: TRABZON: Çaykara, streamsides, on mossy rocks, 230 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7814. - RIZE: Ikizdere; around Güneyce, streamsides, on rocks under *Corylus* , 350 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7829 A. - around Çamlık village, Anzer yayla, edge of *Picea* forest, 1550 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7839 B. - Çayeli; 7,5 km. to Çayeli, in the vicinities of Söğütlü village, rocks, 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7847. - Ardesen; Ardesen to Çamlıhemsin, 11 km., roadside and rocky places, 140 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7854. - Çamlıhemsin; on damp rocks, 440 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7865. - Çamlıhemsin; Palovit valley, on rocks under Picea forest, 800-850 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7866 A. - ARTVIN: Borçka; 49 km. th. from Artvin on the way to Borçka, damp rocks, 670 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7912. - Sarp; 5 km. th. from Kemalpasa on the way to Sarp, roadside,streep rocks, 0 m.,29.9.1993, G.Kaynak and G.Tarımcılar, BULU 7918 B.

A. trichomanes L. subsp. **quadrivalens** D.E. Meyer emend. Lovis

A 8: RIZE: Çamlıhemsin, rocky slopes, 520 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7881. - ARTVIN: Arhavi, Çifteköprü, amongst rocks, 200 m., 27.7.1995, O.Benlioğlu, BULU 7860 B.

A. viride Hudson

A 5: SAMSUN: Bafra; between Alaçam and Çamaltı, on rock fissures, 1000 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9008 B.

A. adiantum-nigrum L.

A 3: BOLU: Devrek; yedigöller National Park, shady and damp rocks, under forest, 310 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9171.

A 4: KASTAMONU: Araç; 10 km. th. from Araç on the way to Daday, edge of mixed forest

(*Quercus, Pinus, Ulmus*), on rocks, 900 m., 22.8.1994, G.Kaynak and G.Tarımcılar, BULU 8906.

A 6: ORDU: Çamas; around Güngören, roadside, rocky slopes, 700 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7740. - Gülyalı; around Kestane village, under *Corylus* plantation, 200 m., 29.7.1995, O.Benlioğlu, BULU 7811.

A 7: GIRESUN: Dereli; between Giresun and Dereli, 8 km. to Çalça, 140 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7761. - on the way to Kümbet yayla , around Yüce village, streamside and rocky slopes, 970 m.,25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7782. - Kesap; between Kesap and Espiye, in the vicinities of Gönüllü village, on walls and stones, 170 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7789 A. - Espiye; around Armelet village, shady rocks in *Alnus* forest, 370 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7795. - TRABZON: Maçka; 9 km. to Değirmendere, along rivulet, rocky places, 850 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7806.

A 8: TRABZON: Çaykara; N slopes of Soğanlı mountain, on rock fissures, 1600 m., 28.7.1995, O.Benlioğlu, BULU 9000. - Çaykara, edge of brook and damp rocks, 230 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7810 A. - RIZE: Çamlıhemsin; 2 km. to Köprübası village, on rocks, 350 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7860. - Palovit valley, rocky places in forest, 750 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7877. - ARTVIN: Artvin - Borçka, 7 km., roadside, damp rocks, 230 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7903. - Sarp; 5 km. th. from Kemalpasa on the way to Sarp, roadside, streep rocks, 0 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7919 A.

A. onopteris L.

A 3: BOLU: Devrek; on the way toYedigöller, 25 km. to Yedigöller National Park, damp rocks under forest, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9154. -Kalkın, on rocks in *Quercus* bushes, 80 m., 29.5.1995, G.Tarımcılar, BULU 9391.

A 4: KASTAMONU: senpazar; between senpazar and Cide, on damp rocks fissures, 890 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9119. - BARTIN: around Karaman, roadside, damp and shady rocks, 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9143 A. - Amasra; between Amasra and Bartın, under maquis, 120 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9143 B.

A 5: SINOP: Ayancık; between Ayancık and Gökçeağç, slopes of Çangal mountain, on rocks under mixer forest of *Platanus, Acer, Ulmus, Quercus,* 330 m., 26.8.1994, BULU 9024.

A 6: ORDU: Ulubey; between Ulubey and Uzunısa, edge of forest, on damp soil, 910 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 7754.

A 7: GIRESUN: on the way to Kümbet yayla , around Çamurköy, streamsides, on rocks, 870 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7761A. - Görele; 7 km w of Gorele, roadside, rocks, 60 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7800 A.

A 8: RIZE: Ikizdere; around Güneyce, streamsides, on rocks under *Corylus*, 350 m., 7.8.1993, G.Kaynak and G.Tarımcılar, BULU 7829. - Çayeli; 7,5 km. to Çayeli, in the vicinities of Söğütlü village, rocks, 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7849. - Ardesen; Ardesen to Çamlıhemsin, 11 km., roadside and rocky places, 140 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7864 C. - ARTVIN: Borçka; 49 km. th. from Artvin on the way to Borçka, damp rocks, 670 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7919 B. - Sarp; 5 km. th. from Kemalpasa on the way to Sarp, roadside, steep rocks, 0 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7919 B.

A. cuneifolium Viv. subsp. **woronowii** (Christ) Viane, Rasbach, Reichstein & Schneller

A 7: TRABZON: Maçka; around Zigana pass, on rock fissures under *P.sylvestris* forest, 2000 m., 26.7.1995, O,Benlioğlu BULU 9384.

A. septentrionale (L.) Hoffm. subsp. **septentrionale**

A 6: ORDU: Gürgentepe; 5 km. th. from Gürtepe on the way to Gürgentepe pass, on damp rocks, 1220 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7732.

A 8: RIZE: Ikizdere; between Ikizdere and Ispir, on rock fissures, 1610 m., 27.7.1995, O.Benlioğlu, BULU 9387.

A. septentrionale (L.) Hoffm. subsp. **caucasicum** Fr.-Jen. et Lovis

A 7: TRABZON: Maçka; around Zigana pass, under *P. slyvestris* forest, 2000 m., 26.7.1995, O.Benlioğlu, BULU 7859.

A 8: TRABZON: Çaykara; above Atabey, on rocks under *Picea* forest, 660 m., 28.7.1995, O.Benlioğlu, BULU 9119. - N slopes of Soğanlı mountain pass, on rock fissures, 2000 m., 28.7.1995, O.Benlioğlu, BULU 9399. - RIZE: Ikizdere; above Ikizdere, on damp rocks, 1000-1100 m., 27.7.1995, G.Kaynak and G.Tarımcılar, BULU 7861.

A. ruta-muraria L. subsp. **ruta-muraria**

A 3: BOLU: 12 km. th. from Bolu on the way to Yeniçağ, under *P. nigra* forest, rocks, 790, 24.7.1995, O.Benlioğlu, BULU 9504.

A 4: KASTAMONU: crossroad to Cide, rocky and stony places, 1050 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9072. - Ilgaz mountain, open places in *Abies* forest, on rocks fissures, 1865 m., 24.7.1995, O.Benlioğlu, BULU 9511 B.

A. scolopendrium L. subsp. **scolopendrium**

A 3: BOLU: Devrek; on the way toYedigöller . 25 km. to Yedigöller National Park, under mixed forest, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9158.

A 4: KASTAMONU: Senpazar to Cide, 20 km., under *Fagus* and *Abies* forest, 850 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9101.- Ağlı; between Ağlı and Senpazar, around Valey, under *Fagus* and *Abies* forest, 640 m., 29.8.1994, G.Kaynak and G.Tarımcılar, BULU 9093. - Cide; between Cide and Kurucasile, around Kumluca, damp places under bushes, 105 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9133. - BARTIN: Kurucasile, damp places and rocks, 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9139.

A 5: SINOP: between Ayancık and Gökçeağaç, screes of Çangal mountain, under mixed forest, 330 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9027.

A 6 : ORDU: Çamas; in the vicinities of Tepeli village, shady places, 400 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7728.

A 7: GIRESUN: around Gönüllü village, under *Corylus* plantation, 170 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7789. - on the way to Kümbet yayla , around Yüceköy, roadside, 970 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7786. - Görele; 7 km. W of Görele, roadside, rocks, 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7798.

A 8: TRABZON: Çaykara; streamsides, damp and wet rocks, 430 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7821 A. - RIZE: Ikizdere; Çamlık, damp rocks, 1300 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7822 A. . - around Çamçavus, shady places under forest, 830 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7831 B. - Ardesen; between Ardesen and Çamlıhemsin, 12 km. to Çamlıhemsin, under mixed forest, 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7858 A. - ARTVIN: 49 km.from Artvin on the way to Borçka, damp rocks, 670 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7810. - Sarp; Kemalpasa to Sarp, 5 km., roadside, steep rocks, 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7916.

A. ceterach L. subsp. **ceterach**

A 3: BOLU: Yedigöller, on rocks in shady places, 250 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9153.

A 4: KASTAMONU: Inebolu; between Ağlı and Cide, edge of forest, on rocks, 1050 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9073.

A 5: SINOP: Boyabat; between Saraydüzü and Kargı, around Yeniceköy, rocks and edge of *Pinus* forest, 320 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 8971. - ÇORUM: Osmancık; around Eymir village, edge of water, rocks, 420 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 8980. - AMASYA: 10 km. th. from Amasya on the way to Tasova, roadside,rocks, 385 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 8988.

A 8: TRABZON: Çaykara; above Atabey, on rock fissures under *Picea* forest, 660 m., 28.7.1995, O.Benlioğlu, BULU 8992.

WOODSIACEAE

Matteucia struthiopteris (L.) Tod.

A 6: ORDU: Gülyalı, around Kestane village, under *Corylus* plantation, 200 m., 29.7.1995, O.Benlioğlu, BULU 9423.

A 7: GIRESUN: on the way to Kümbet yayla, around Yüce village, streamsides, damp and shady places, 890 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7770.

A 8: ARTVIN: Arhavi; Çifteköprü, under *Fagus, Carpinus, Alnus* forest, 200 m., 27.7.1995, O.Benlioğlu, BULU 9424.

Athyrium distentifolium Tausch ex Opiz

A 6: ORDU: Çamas; around Güngören, roadside, 700 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7738.A.

A 7: GIRESUN: Kümbet yayla, rocky places, under *Picea* forest, 1650 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7775.

A 8: TRABZON: between Çaykara and Bayburt, Soğanlı mountain, alpine meadows, 2600 m., 28.7.1995, O.Benlioğlu, BULU 7850. - Çaykara; on the way Uzungöl road, under *Alnus* forest, 230 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU7738. - RIZE: Çamlıhemsin; above Çamlıhemsin, valley, rocky slopes, 520 m.,28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7878.

A. filix-foemina (L.) Roth

A 3: BOLU: Yedigöller, under mixed forest, 310 m., 28.81994, G.Kaynak and G.Tarımcılar, BULU 9174.

A 4: KASTAMONU: between Kastamonu and Tosya; 9 km. th. from Akkaya on the way to Tosya, streamsides, 880 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8948. - Senpazar; between Senpazar and Cide, 20 km. to Cide, under mixed forest, 890 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9112. - BARTIN: around Karaman, roadside, maquis, 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9142.

A 5: SINOP: Ayancık; NW slopes of Çangal mountain, edge of forest, 1090 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9034.

A 6: ORDU: Çamas, under Corylus plantation, 490 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7733. - Çamas; around Güngören, roadside, 700 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7739.

A 7: GIRESUN: Dereli; Tasocağı location, roadside, 90 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7756. - on the way to Kümbet yayla , around Yüceköy, shady and damp places, 970 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7780. - Espiye; Armelet village, under *Corylus* plantation, 370 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7794.

A 8: TRABZON: Çaykara, streamside, damp rocks, 230 m., 27.8.1993, G.Kaynak and G.,Tarımcılar, BULU 7810. - RIZE: Ikizdere; Güneyce, streamsides and rocks, under *Corylus* plantation, 350 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7826. - Çamçavus, under forest, 830 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7831. - Çamlık, edge of forest, 1300 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7837. - Çayeli; 7,5 km. to Çayeli, in the vicinities of Söğütlü village, rocks, 0 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7843. - Ardesen; between Ardesen and Çamlıhemsin, 12 km. to Çamlıhemsin, roadside, 440 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU

7869. - ARTVIN: between Artvin and Borçka, wet rocky slopes, 230 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7905.- Sarp; Kemalpasa to Sarp, 5 km., roadside, streep rocks, 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7921.

Gymnocarpium dryopteris (L.) Newman

A 8: TRABZON: between Çaykara and Bayburt; N slopes of Soğanlı mountain, amongst rocks and stones, 1600 m., 28.7.1995, O.Benlioğlu, BULU 7874.

Cystopteris fragilis (L.) Bernh.

A 5: KASTAMONU: Tosya; between Tosya and Çiftlik, rocks under *Pinus* and *Abies* forest, 1560 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 7862.

A 7: TRABZON: Maçka; above Hamsiköy, on rock fissures under *Picea* forest, 1600 m., 26.7.1995, O.Benlioğlu, BULU 9403.

Woodsia alpina (Bolton) S.F.Gray

A 8: TRABZON: between Çaykara and Bayburt, N slopes of Soğanlı mountain, amongst rocky and stones, 2000 m., 26.7.1995, O.Benlioğlu, BULU 9404.

DRYOPTERIDACEAE

Polystichum lonchitis (L.) Roth

A 4: ZONGULDAK: Yenice; between Yenice and Karabük, amongst rocks, 900 m., 30.9.1995, G.Tarımcılar, BULU 9410.

A 7: TRABZON: Maçka; around Zigana pass, amongst rocks under *P. slyvestris* forest, 2000 m., 26.7.1995, O.Benlioğlu, BULU 9421.

A 8: TRABZON: Çaykara; between Çaykara and Bayburt, N slopes of Soğanlı mountain, amongst rocks and stones, 1600 m., 28.7.1995, O.Benlioğlu, BULU 9422.

P. woronowii Fomin

A 3: ZONGULDAK: Kızılcapınar; around Sinitli village, 80 m., 30.9.1995, G.Tarımcılar, BULU 9400. - near Düzpelit, maquis, 270 m., 30.9.1995, G.Tarımcılar, BULU 9406. - between Zonguldak and Muslu, maquis and meadows, 16 m., 30.9.1995, G.Tarımcılar, BULU 9414.

A 8: RIZE: Çamlıhemsin; Palovit valley, roadside, 750-800 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7893.

P. aculeatum (L.) Roth

A 3: BOLU: Devrek; on the way toYedigöller, 25 km. to Yedigöller National Park, 230 m., 28.81994, G.Kaynak and G.Tarımcılar, BULU 9160.

A 4: KASTAMONU: between Ağlı and Cide, around Hıdırlar village, under *Fagus* forest, 790 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9083. - Senpazar; between Senpazar and Cide, edge of forest, 960 m, 27.8.1994, BULU 9104.

.A 5: SINOP: Ayancık, Çangal mountain, 1090 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9045.

A 7: GIRESUN: on the way to Kümbet yayla ,Yüceköy, roadside, 970 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7785.

A 8: RIZE: Çamlıhemsin, roadside, edge of forest, 440 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7872. - above Çamlıhemsin, valley, rocky slopes, 520 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7879. - ARTVIN: Borçka, wet rocky slopes, 230 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7906.

P. braunii (Spenner) Fee

A 8: TRABZON: between Çaykara and Bayburt; N slopes of Soganlı mountain, amongst rocks, 1600 m., 28.7.1995, O.Benlioğlu, BULU 7906.

A 8: RIZE: Ikizdere; between Ikizdere and Ispir, under rocks, 1610 m., 27.7.1995, O.Benlioglu, BULU 9415.

P. setiferum (Forskal) Woynar

A 3: ZONGULDAK: between Zonguldak and Ereğli, 5 km to Alaplı, under Corylus plantation, o m., 30.9.1995, G.Tarımcılar, BULU 9393. - Kızılcapınar, around Sinitli village, 80 m.,

30.9.1995, G.Tarımcılar, BULU 9396. - BOLU: Yedigöller National Park, roadside, 310 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9172.

A 4: KASTAMONU: Cide; between Cide and Kurucasile, roadside, 105 m., 27.8.1994, BULU 9129. - Senpazar; between Senpazar and Cide, 20 km. to Cide, edge of forest, 890 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9100. - BARTIN: around Karaman, maquis, 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9140.

A 5: SINOP: Ayancık; crossroad to Yenikonak, maquis, 165 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9020. - between Ayancık and Gökçeağaç, W slopes of Çangal mountain, under mixed forest of *Platanus, Acer, Quercus*, 330 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9023.

A 6: ORDU: Çamas; around Tepeli village, shady places, 400 m., 24.8.1993, G.Kaynak and G.Tarımcılar, BULU 7731. - SAMSUN: Bafra; between Alaçam and Kızlan, roadside, 650 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 7765.

A 7: GIRESUN: on the way to Kümbet yayla, around Yüceköy, shady and damp places, 970 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7781 B. - Kesap, roadside, rocks, 0 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7787 A. - Görele; 7 km. W of Görele, roadside, rocks, 60 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7789.

A 8: TRABZON: Çaykara, streamsides, damp rocks, 230 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7813. - RIZE: Ikizdere; around Güneyce, near rivulet, rocks, under Corylus plantation, 350 m., 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7828. - Çayeli; 7,5 km. to Çayeli, in the vicinities of Söğütlü village, rocks, 0 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7845. - Çamlıhemsin; roadside, 440 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7886 B. - ARTVIN: Borçka; damp rocky places, 160 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7893. - 49 km. th. from Artvin on the way to Borçka, damp rocks, 670 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7911.

Dryopteris filix - mas (L.) Schott

A 3: BOLU: Devrek; on the way to Yedigöller, 25 km.toYedigöller National Park, under forest, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9176.

A 4: KASTAMONU: Araç; 12 km. th. from Araç on the way to Daday, mixed forest of *Pinus, Quercus, Ulmus*, 1040 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8907. - Akkaya; 19 km. th. from Akkaya on the way to Tosya, slopes of Ilgaz mountain, under forest, 1500 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8942. - Tosya; around Çiftlik, under *Abies* and *Pinus* forest, 1560 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8949. - Ağlı; between Ağlı and Senpazar, around Sada village, on rocks in *Abies* forest, 920 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9079. - between Ağlı and Cide; around Hıdırlar village, under *Fagus* forest, 790 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9085. - between Ağlı and Senpazar, around Valay, under *Fagus, Abies* forest, 640 m., 29.8.1994, G.Kaynak and G.Tarımcılar, BULU 9089. - Cide; Cide-Kurucasile, roadside, 105 m., 27.8.1994, G.Kaynak and G.Tarımcılar, BULU 9134.

A 5: SINOP: Ayancık; Çangal mountain, above Ayancık, 1090 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9047. - between Ayancık and Gökçeağaç, W slopes of Çangal mountain, under mixed forest of *Acer, Platanus, Quercus*, 330 m., 26.8.1994, G.Kaynak and G.Tarımcılar, BULU 9033. - Gürgendibi, under forest, 70 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9015. - SAMSUN: Alaçam to Kızlan, 20 km., edge of forest, 650 m., 25.8.1994, G.Kaynak and G.Tarımcılar, BULU 9007.

A 6: ORDU: Çamas; around Uzunali, shady and damp places, 900-950 m., 24.8.1994, G.Kaynak and G.Tarımcılar, BULU 7797.

A 7: GIRESUN: Kesap, damp rocky places, 0 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7787 B. - around Gönüllü village, under *Corylus* plantation, 170 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7789 B. - Görele; 7 km. W of Görele, rocks, roadside, 60 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7797.

A 8: RIZE: crossroad to Ikizdere, streamsides, rocks, 27.8.1993, G.Kaynak and G.Tarımcılar, BULU 7823. - Çamlıhemsin; roadside, shady rocky places, 440 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7868. - ARTVIN: Borçka, damp rocks, 230 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7907. - 49 km. th. from Artvin on the way to Borçka, damp rocks, 670 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7909.

D. affinis (Lowe) Fr.-Jen. subsp. **borreri** (Newman) Fr.-Jen.

A 3: BOLU: Devrek; on the way to Yedigöller, 25 km. to Yedigöller National Park, under mixed forest, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9161.

A 4: KASTAMONU: between Kastamonu and Tosya, forest, 950 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8927.

A 5: KASTAMONU: between Tosya and Tasköprü, mixed forest, 1100 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8949.

A 7: GIRESUN: Bulancak to Giresun, 5 km., under *Fagus- Castanea* forest, waterside, 10 m., 25.7.1995, O.Benlioğlu, BULU 4334.

D. oreades Fomin

A 7: TRABZON: Maçka, around Zigana pass, amongst rocks in *P. slyvestris* forest, 2000 m., 26.7.1995, O.Benlioğlu, BULU 9417. - GIRESUN: between Espiye and Tirebolu, under *Castanea, Fagus* forest, 20 m., 25.7.1995, O.Benlioğlu, BULU 7870.

A 8: ARTVIN: Arhavi; around Dikyamaç village, under mixed forest of *Carpinus, Fagus, Alnus* with shrub layer of *Corylus, Rhododendron,* 450 m., 27.7.1995, O.Benlioğlu, BULU 9118.

D. caucasica (A.Br.) Fr.-Jen.

A 3: BOLU: Bolu to Abant lake, 3 km., under *Abies* forest, 1400 m., 24.7.1995, O.Benlioglu, BULU 9519. - Devrek; on the way to Yedigöller, 25 km. to Yedigöller National Park, in mixed forest, 230 m., 28.8.1994, G.Kaynak and G.Tarımcılar, BULU 9164.

A 4: KASTAMONU: between Tosya and Tasköprü, mixed forest, 1100 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 9094.

D. dilatata (Hoffm.) A. Gray

A 5: KASTAMONU: Tosya; between Tosya and Çiftlik, underwood, 1120 m., 21.8.1994, G.Kaynak and G.Tarımcılar, BULU 8960.

A 7: GIRESUN: on the way to Kümbet yayla, around Çamurköy, streamsides, 870 m., 25.8.1993, G.Kaynak and G.Tarımcılar, BULU 7757. - TRABZON: Maçka; Meryemana, mixed forest of *Fagus, Carpinus, Alnus, Picea,* 1700 m., 26.7.1995, O.Benlioğlu, BULU 9520.

A 8: ARTVIN: Arhavi; before Dikyamaç village, in mixed forest of *Fagus, Carpinus, Alnus* with shrub layer of mainly *Ribes, Rhododendron,* 200 m., 27.7.1995, O.Benlioğlu, BULU 9521.

D. expansa (C.Presl) Fr.-Jen. & Jermy

A 8: ARTVIN: Arhavi; Çifteköprü, under mixed forest of *Fagus, Carpinus, Alnus* with shrub layer mainly *Ribes, Rhododendron,* 200 m., 27.7.1995, O.Benlioglu, BULU 7760.

BLECHNACEAE

Blechnum spicant (L.) Roth

A 7: GIRESUN: Gönüllü village, under *Corylus* plantation, 170 m., 26.8.1993, G.Kaynak and G.Tarımcılar, BULU 7790. - between Kesap and Espiye, under *Fagus, Carpinus, Castanea* forest, 30 m., 25.7.1995, BULU 9522.

A 8: RIZE: Çamlıhemsin, on damp rocks, 120 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7854. - Çayeli; around Söğütlü village, 0 m., 28.8.1993, G.Kaynak and G.Tarımcılar, BULU 7848. - ARTVIN: between Artvin and Borçka, roadside, damp rocks, 160 m., 29.8.1993, G.Kaynak and G.Tarımcılar, BULU 7879. - Arhavi; before Dikyamaç village, in mixed forest of *Fagus, Carpinus, Alnus* forest, 450 m., 27.7.1995, O.Benlioğlu, BULU 9523.

EASTERN BLACK SEA REGION

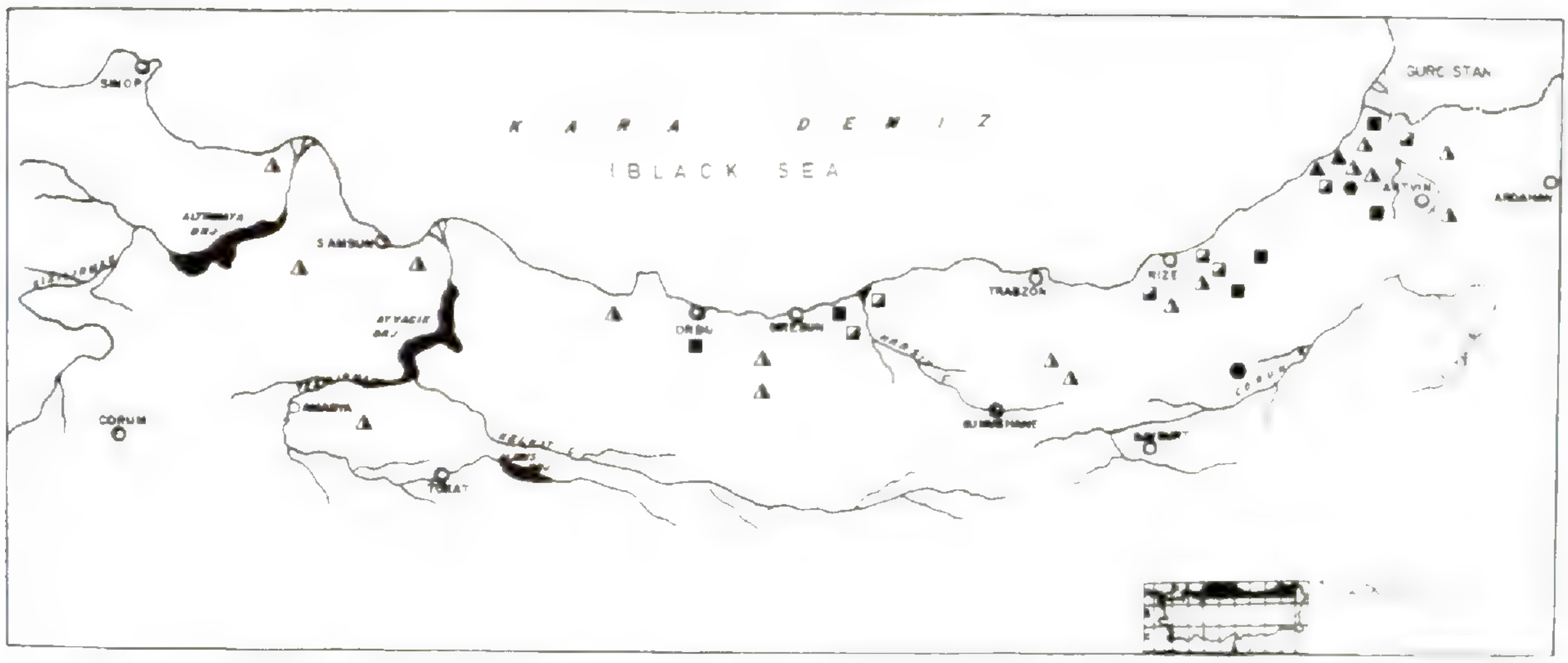

Figure 1: The distribution of *O regalis*, *P cretica*, *C. marantae* subsp. *marantae*, *C crispa*, *P aquilinum* and *B. spicant* in Eastern Black Sea

▲ *Osmunda regalis*
■ *Pteris cretica*
● *Cheilanthes marantae* subsp *marantae*
● *Cryptogramma crispa*
▲ *Pteridium aquilinum*
◪ *Blechnum spicant*

EASTERN BLACK SEA REGION

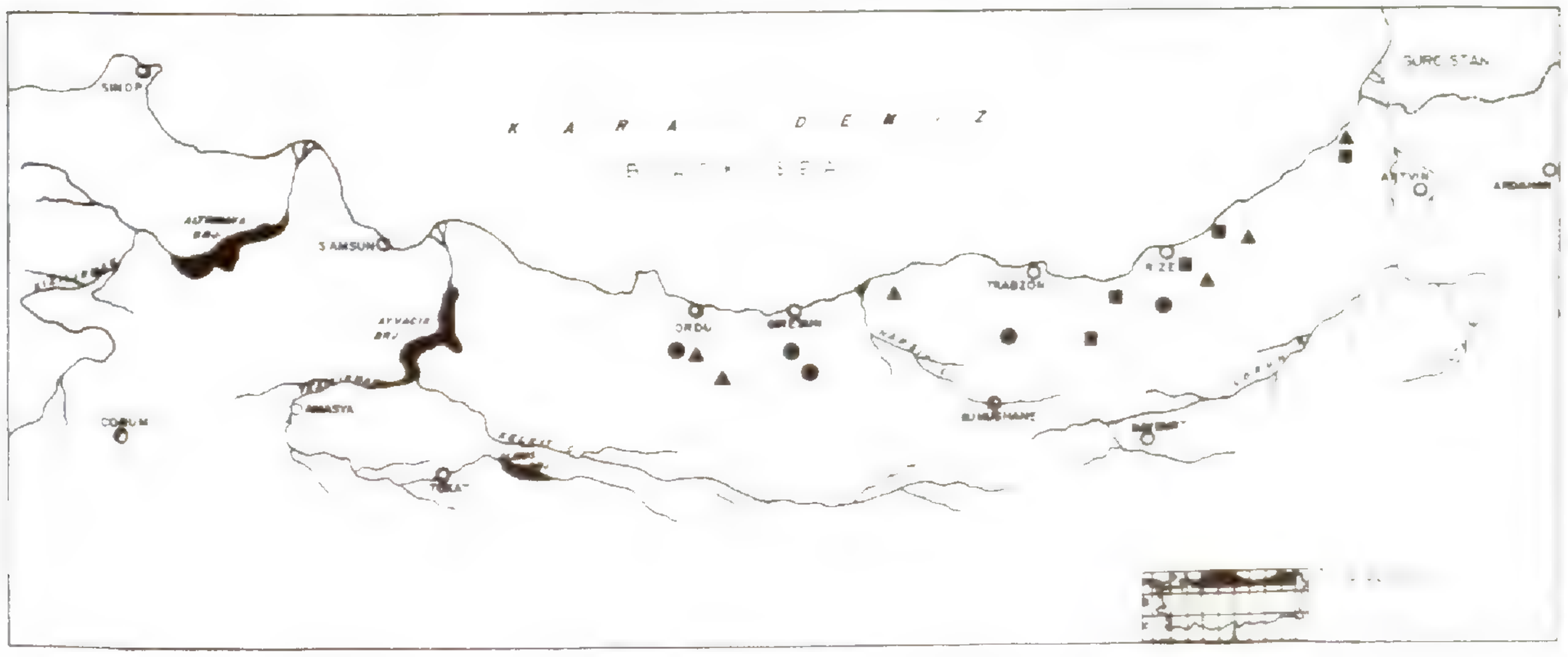

Figure 2: The distribution of *P vulgare*, *P interjectum* and *P cambricum* in Eastern Black Sea region

▲ *Polypodium vulgare*
■ *Polypodium interjectum*
● *Polypodium cambricum*

WESTERN BLACK SEA REGION

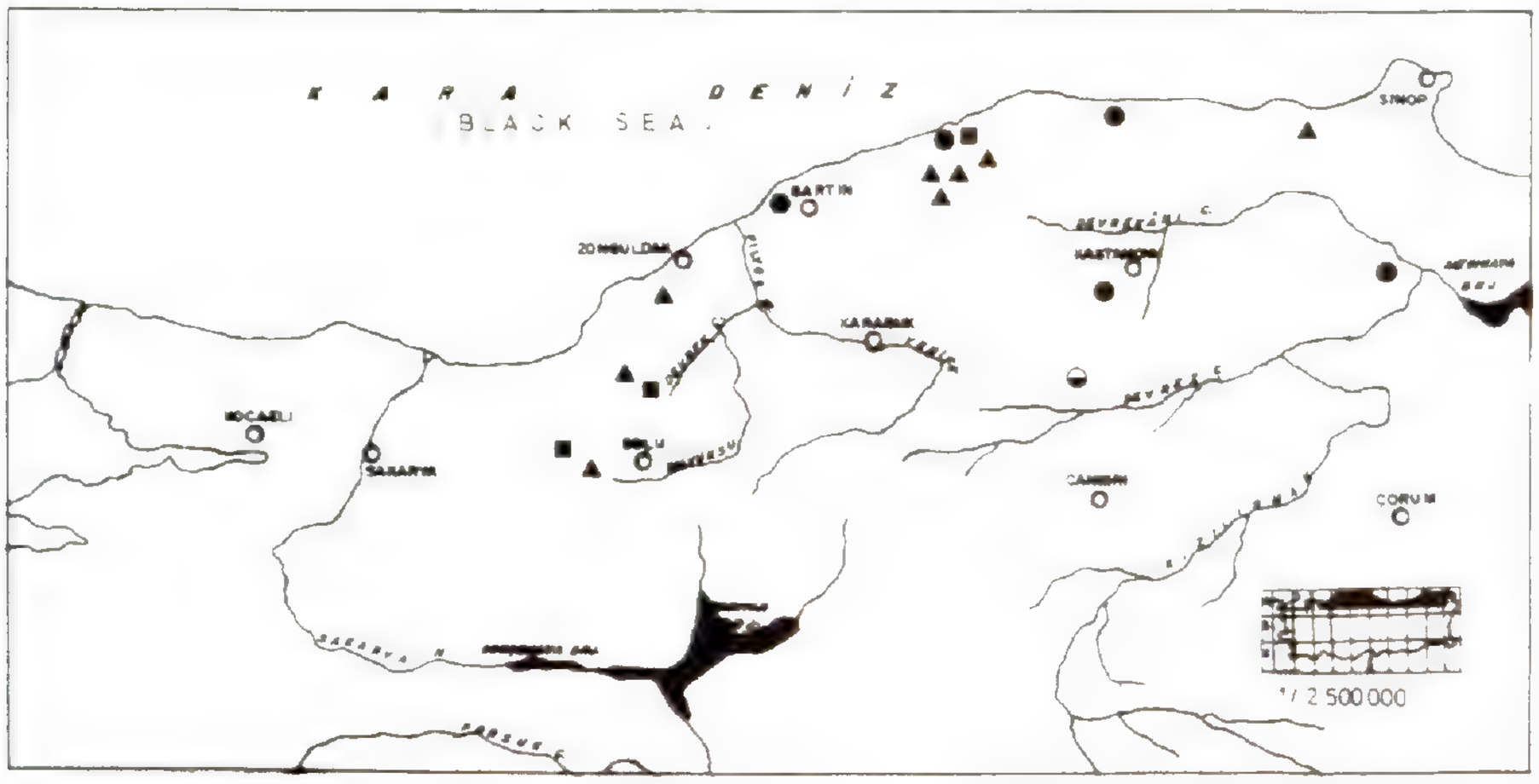

Figure 3: The distribution of *P. vulgare*, *P. interjectum*, *P. cambricum*, *A. capillus-veneris* and *C. fragilis* in Western Black Sea region.

▲ *Polypodium vulgare*
■ *Polypodium interjectum*
● *Polypodium cambricum*
● *Adiantum capillus-veneris*
◒ *Cystopteris fragilis*

EASTERN BLACK SEA REGION

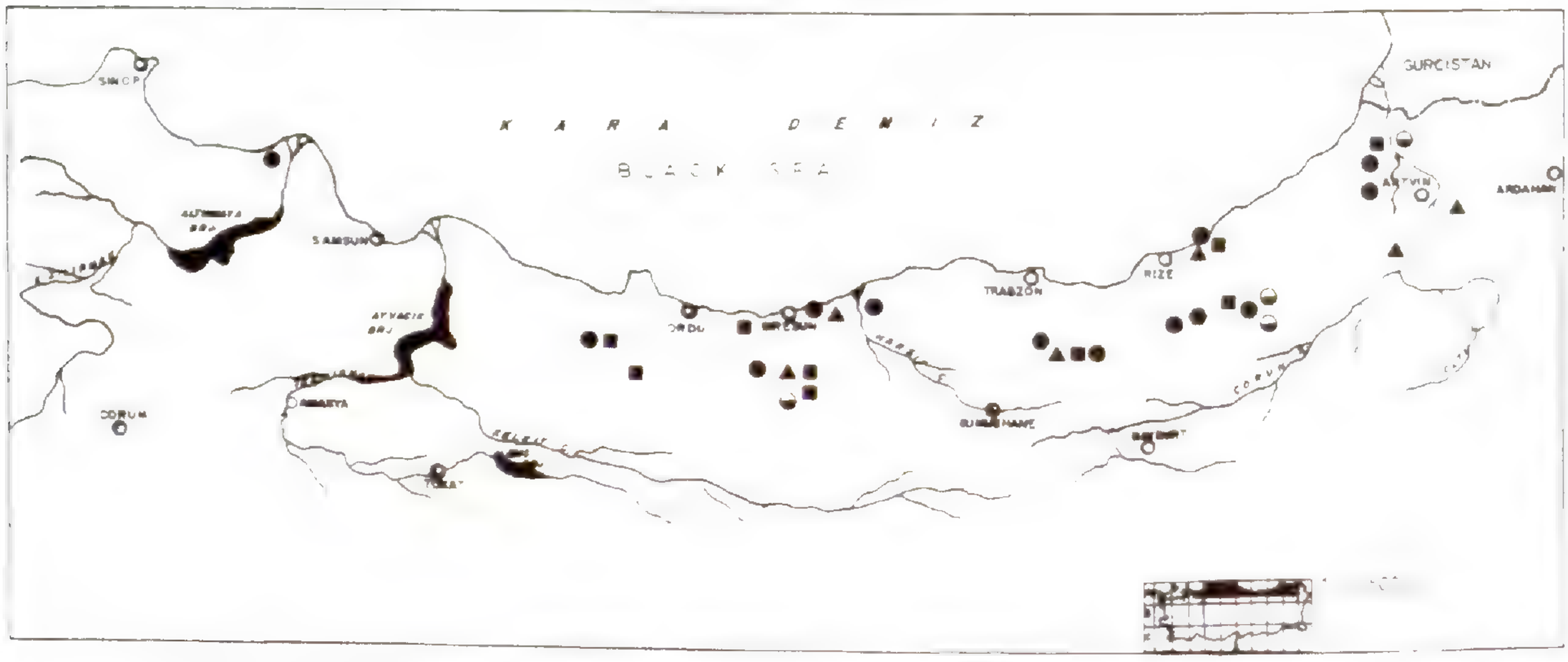

Figure 4: The distribution of *A. capillus-veneris*, *O. limbosperma*, *P. connectilis*, *P. setiferum* and *P. aculeatum* in Eastern Black Sea region.

▲ *Adiantum capillus-veneris*
■ *Oreopteris limbosperma*
● *Phegopteris connectilis*
◒ *Polystichum aculeatum*
● *Polystichum setiferum*

WESTERN BLACK SEA REGION

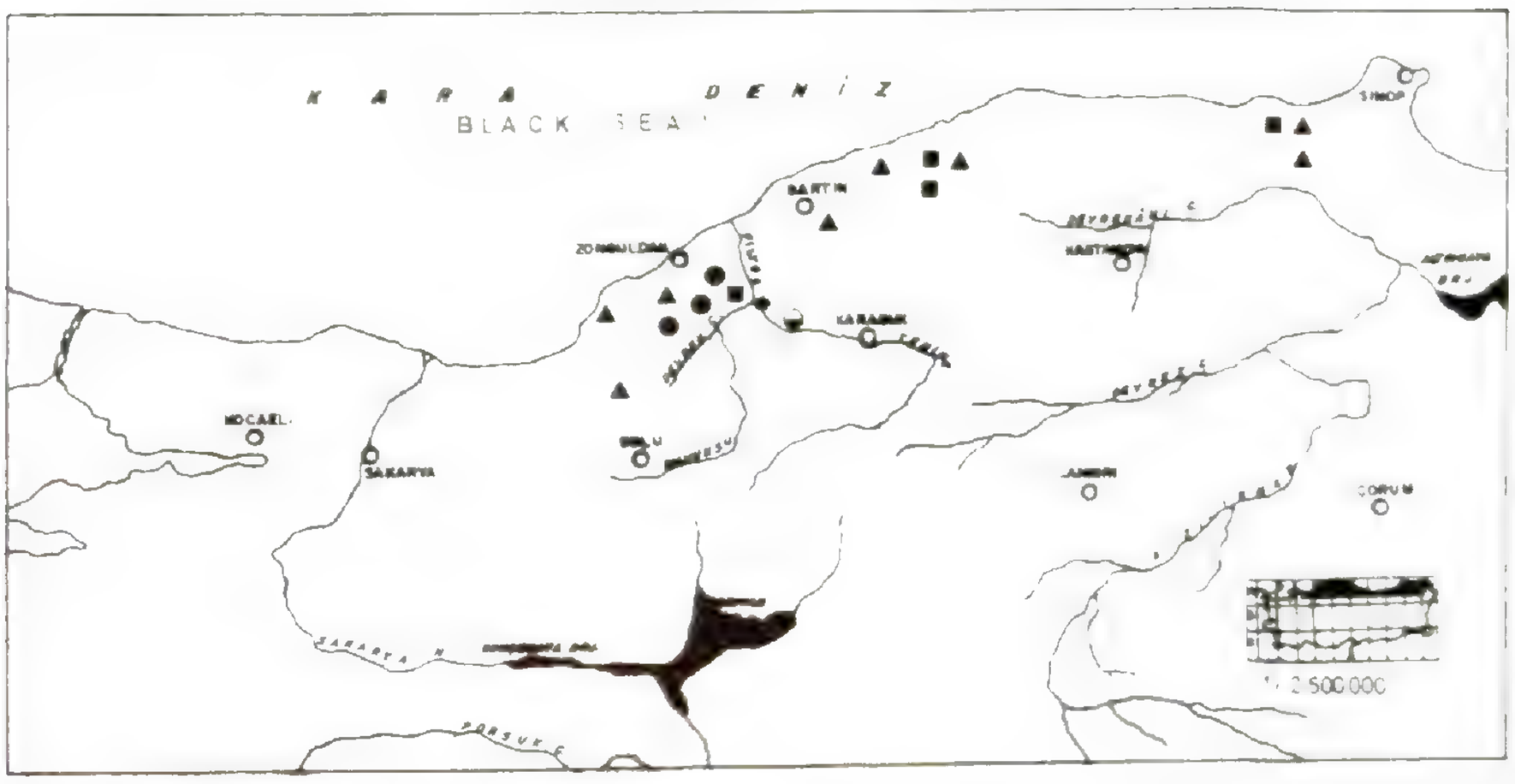

Figure 5. The distribution of *P. setiferum*, *P. aculeatum*, *P. woronowii* and *P. lonchitis* in Western Black Sea region.

▲ *Polystichum setiferum*
● *Polystichum aculeatum*
■ *Polystichum woronowii*
◒ *Polystichum lonchitis*

EASTERN BLACK SEA REGION

Figure 6. The distribution of *Asplenium* × *uneifolium* subsp. *woronowii*, *A.* × *adulterinum*, *A. onopteris* and *A.* × *souchei* in Eastern Black Sea region.

▲ *Asplenium* × *uneifolium* subsp. *woronowii*
● *Asplenium* × *adulterinum*
■ *Asplenium onopteris*
◒ *Asplenium* × *souchei*

EASTERN BLACK SEA REGION

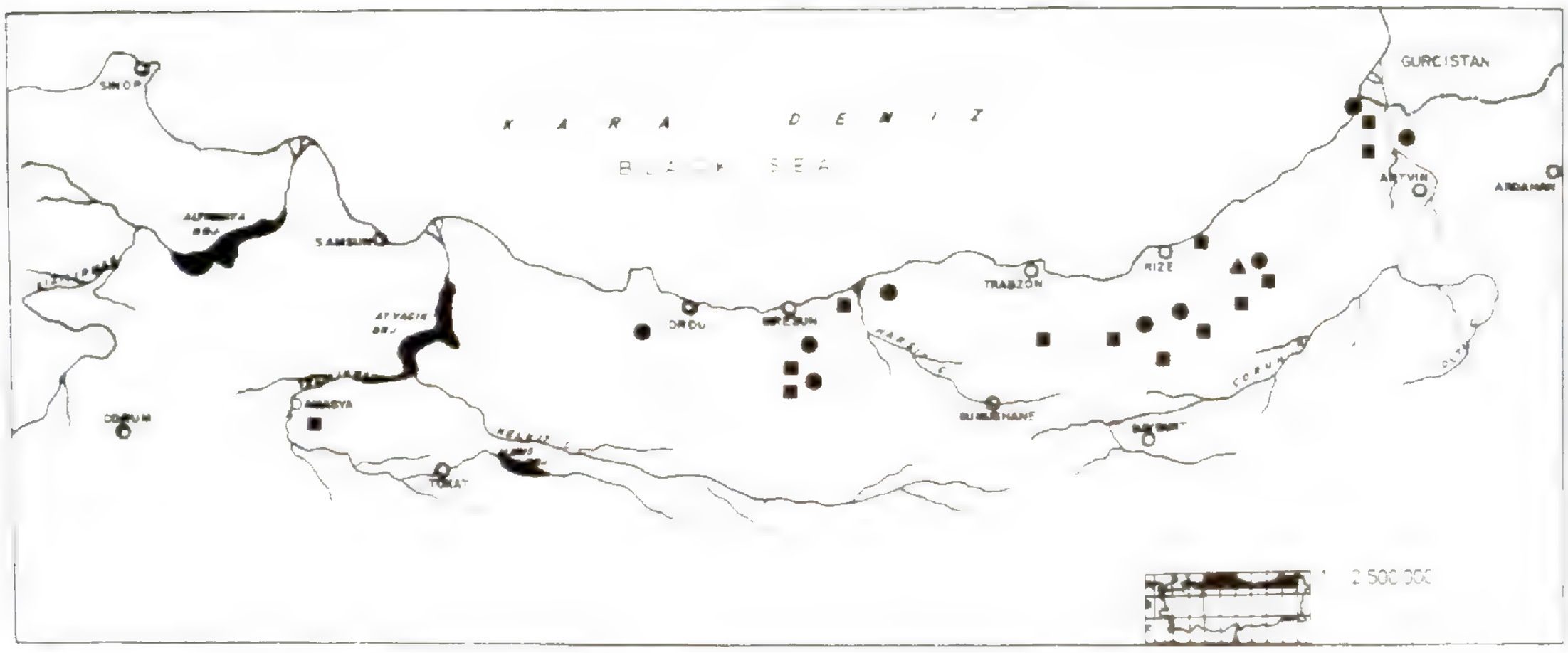

Figure 7: The distribution of *A trichomanes* subsp. *trichomanes*, *A. trichomanes* subsp. *quadrivalens* and *A scolopendrium* subsp. *scolopendrium* in Eastern Black Sea region.

■ *Asplenium trichomanes* subsp. *trichomanes*
▲ *Asplenium trichomanes* subsp. *quadrivalens*
● *Asplenium scolopendrium* subsp *scolopendrium*

WESTERN BLACK SEA REGION

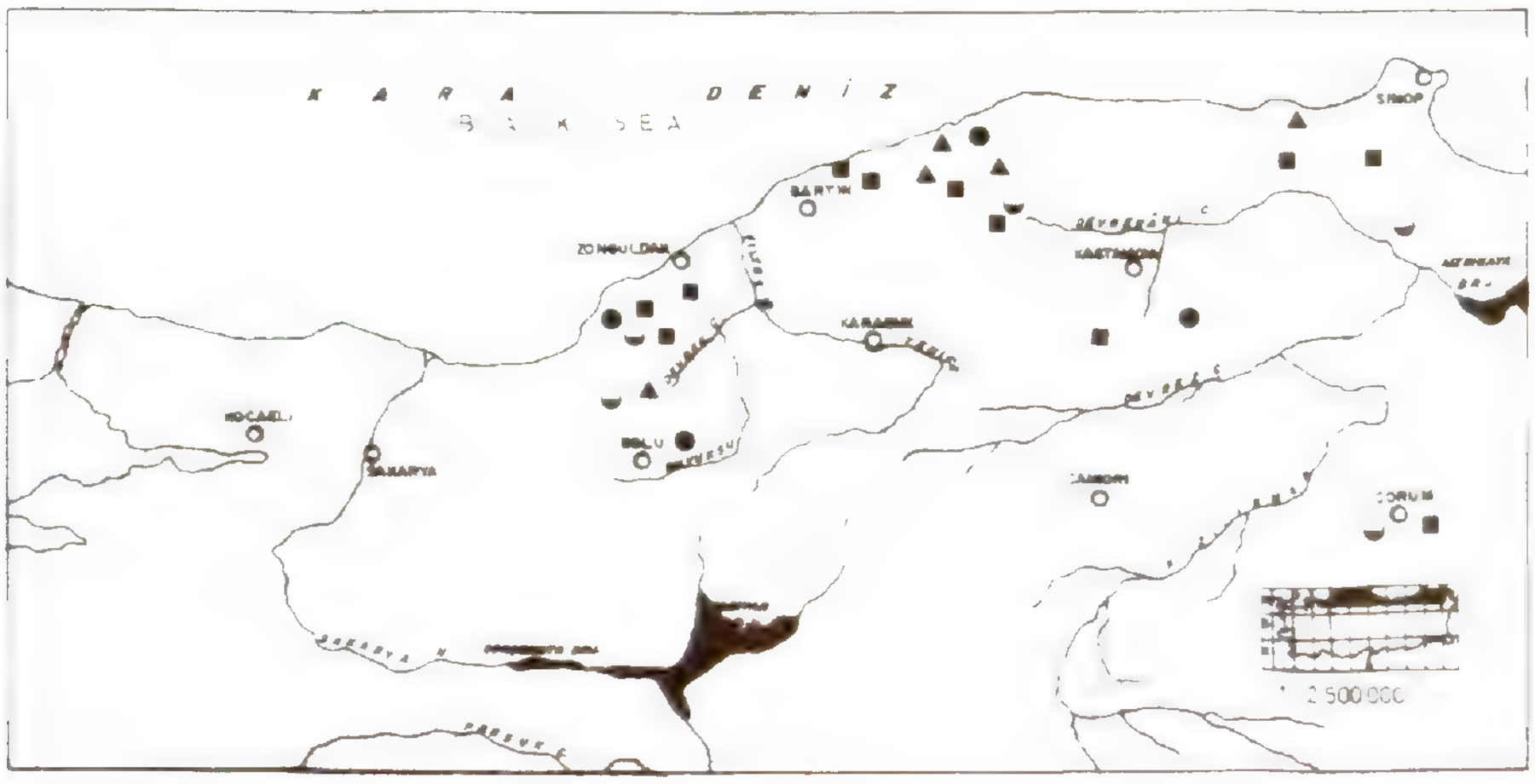

Figure 8: The distribution of *A trichomanes* subsp. *trichomanes*, *A scolopendrium* subsp. *scolopendrium*, *A. ruta-muraria* subsp. *ruta muraria* and *A ceterach* subsp *ceterach* in Western Black Sea region

■ *Asplenium trichomanes* subsp. *trichomanes*
▲ *Asplenium scolopendrium* subsp. *scolopendrium*
● *Asplenium ruta muraria* subsp *ruta-muraria*
◒ *Asplenium ceterach* subsp *ceterach*

EASTERN BLACK SEA REGION

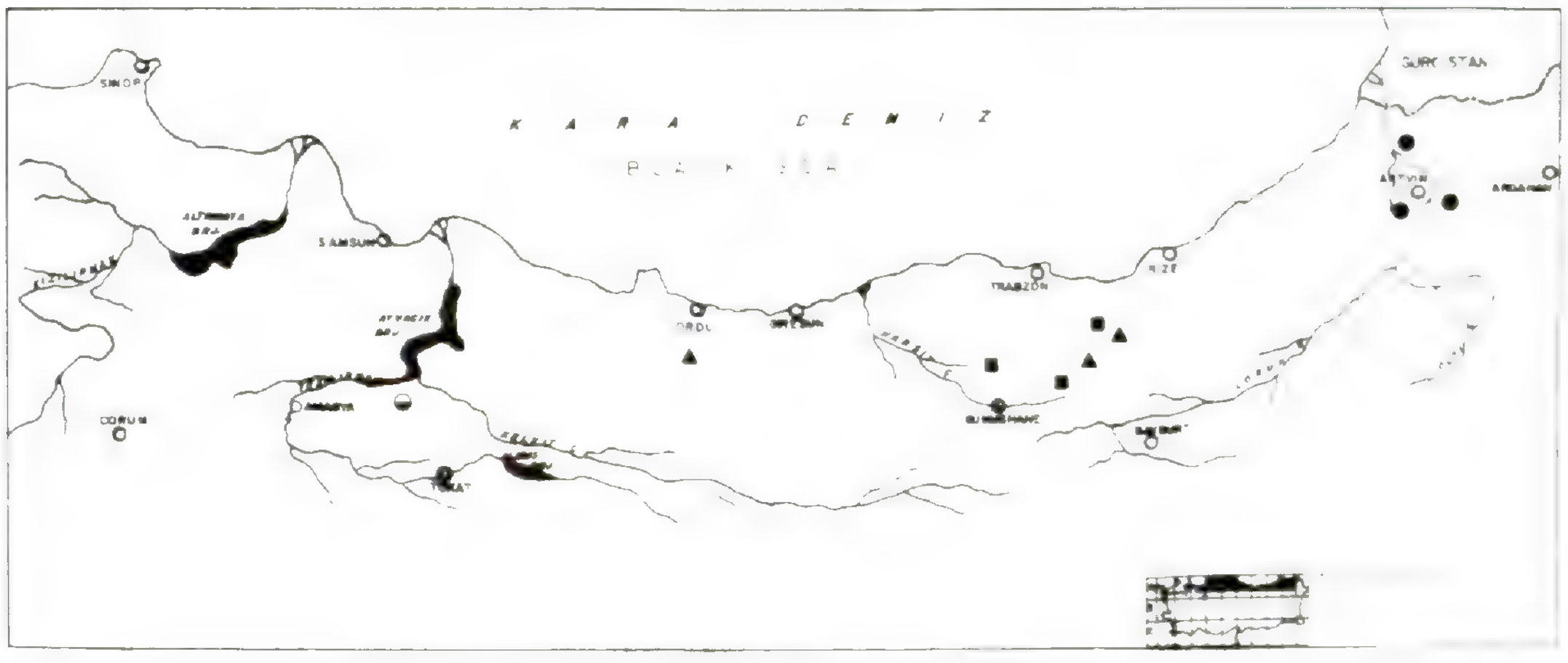

Figure 9: The distribution of *A. septentrionale* subsp. *septentrionale*, *A. septentrionale* subsp. *caucasicum*, *A. ruta-muraria* subsp. *ruta-muraria* and *A. ceterach* subsp. *ceterach* in Eastern Black Sea region

▲ *Asplenium septentrionale* subsp. *septentrionale*
■ *Asplenium septentrionale* subsp. *caucasicum*
● *Asplenium ruta-muraria* subsp. *ruta-muraria*
◒ *Asplenium ceterach* subsp. *ceterach*

WESTERN BLACK SEA REGION

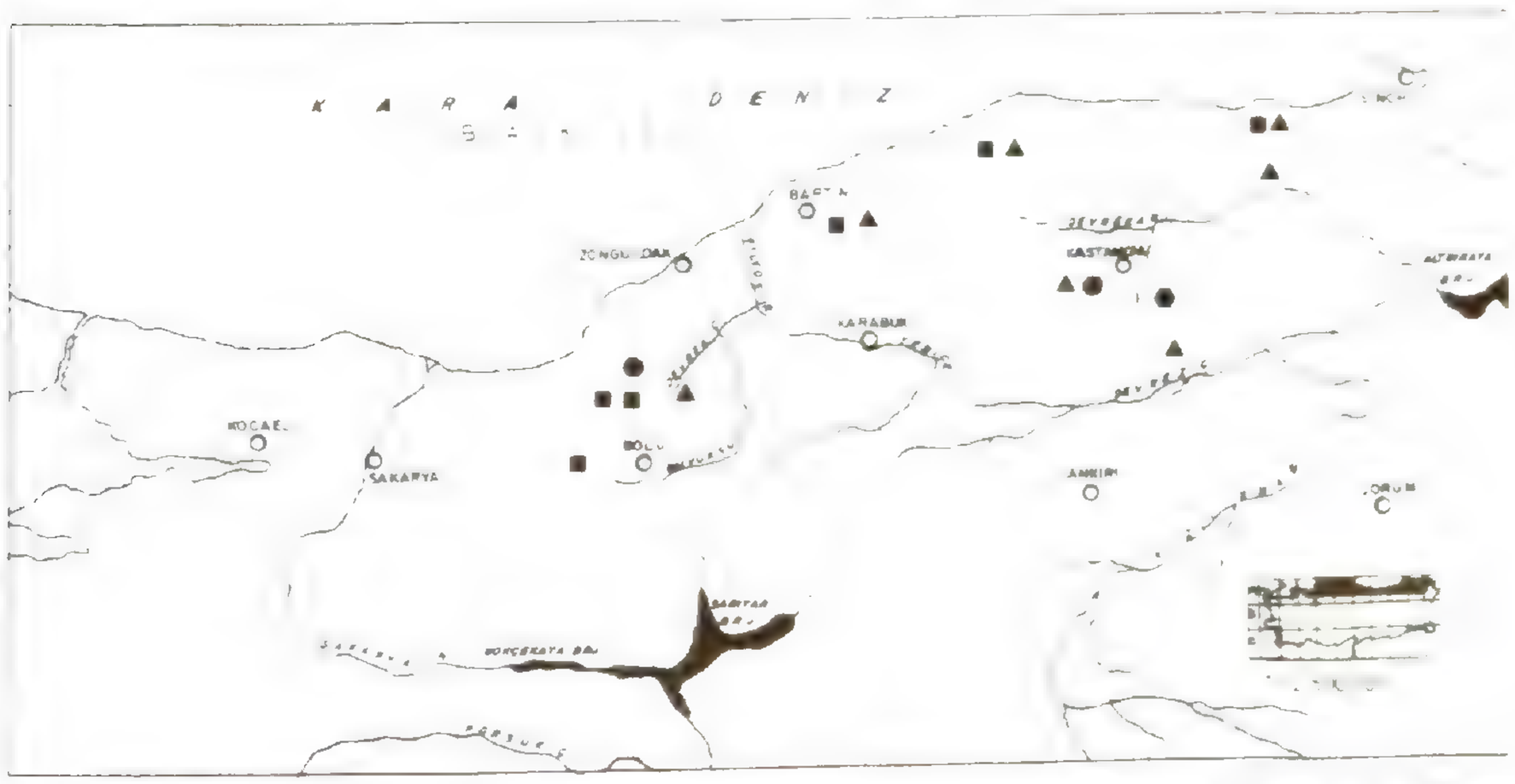

Figure 10: The distribution of *A. adiantum-nigrum*, *A. onopteris*, *A. filix-femina* [illegible] Black Sea region

● *Asplenium adiantum-nigrum*
■ *Asplenium onopteris*
▲ *Athyrium filix-femina*
● *Cystopteris fragilis*

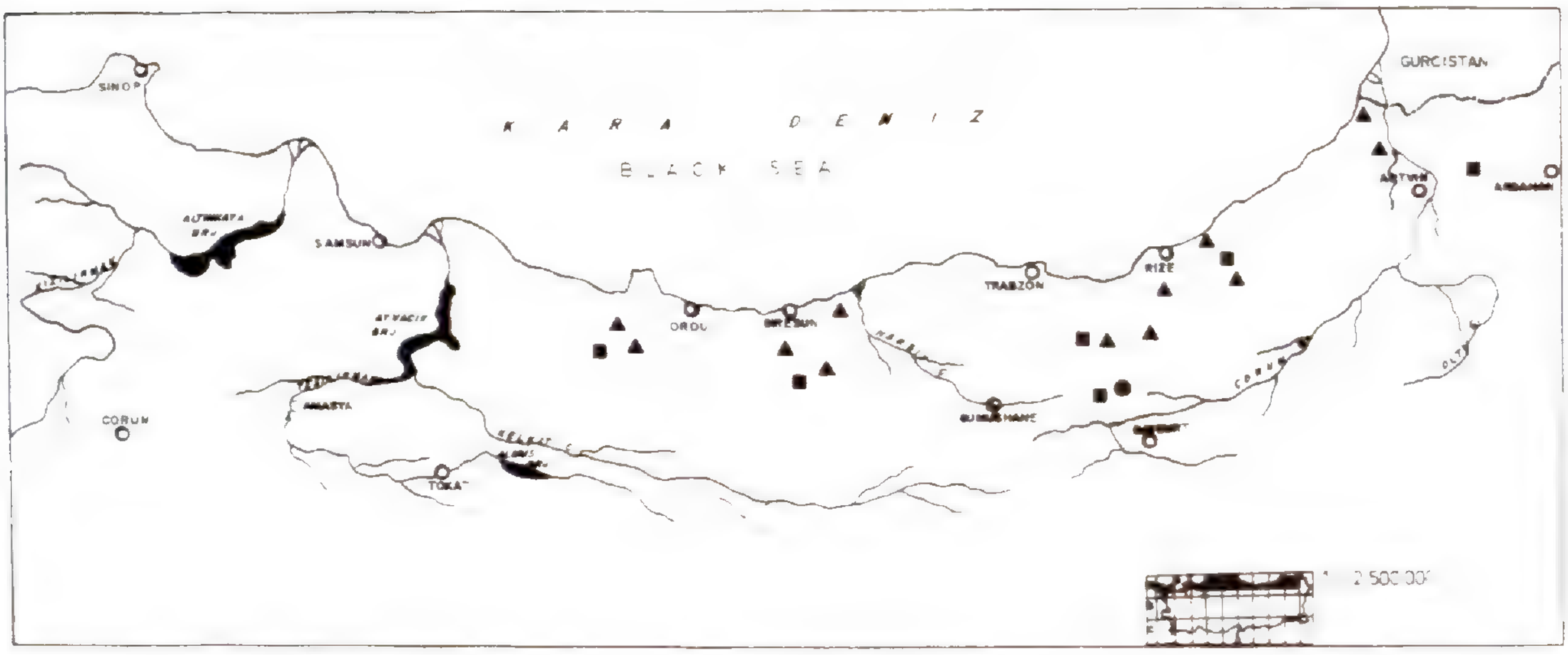

Figure 11: The distribution of *A. filix-foemina*, *A. distentifolium* and *G. dryopteris* in Eastern Black Sea region

▲ *Athyrium filix-foemina*
■ *Athyrium distentifolium*
● *Gymnocarpium dryopteris*

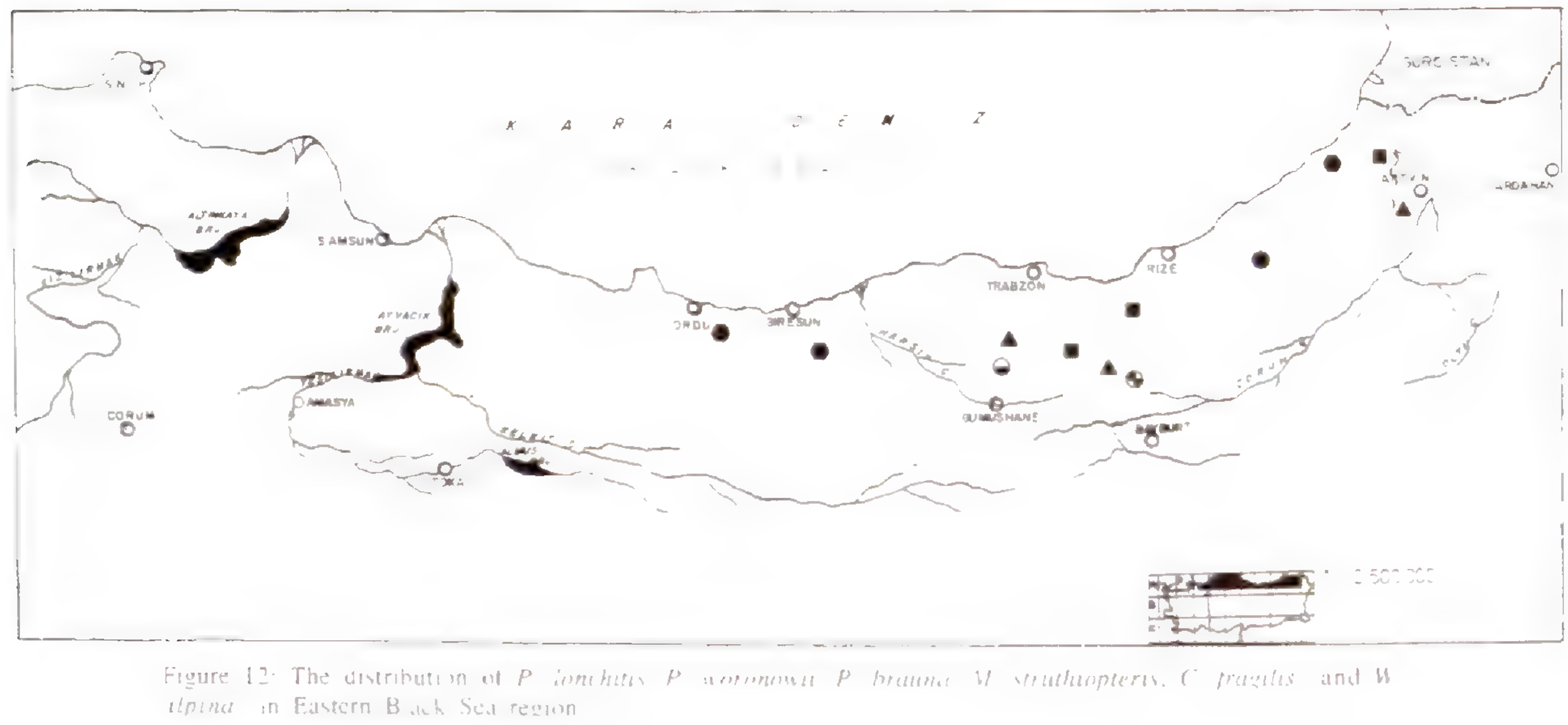

Figure 12: The distribution of *P. lonchitis*, *P. woronowii*, *P. braunii*, *M. struthiopteris*, *C. fragilis* and *W. alpina* in Eastern Black Sea region

▲ *Polystichum lonchitis*
● *Polystichum woronowii*
■ *Polystichum braunii*
● *Matteuccia struthiopteris*
◒ *Cystopteris fragilis*
◔ *Woodsia alpina*

EASTERN BLACK SEA REGION

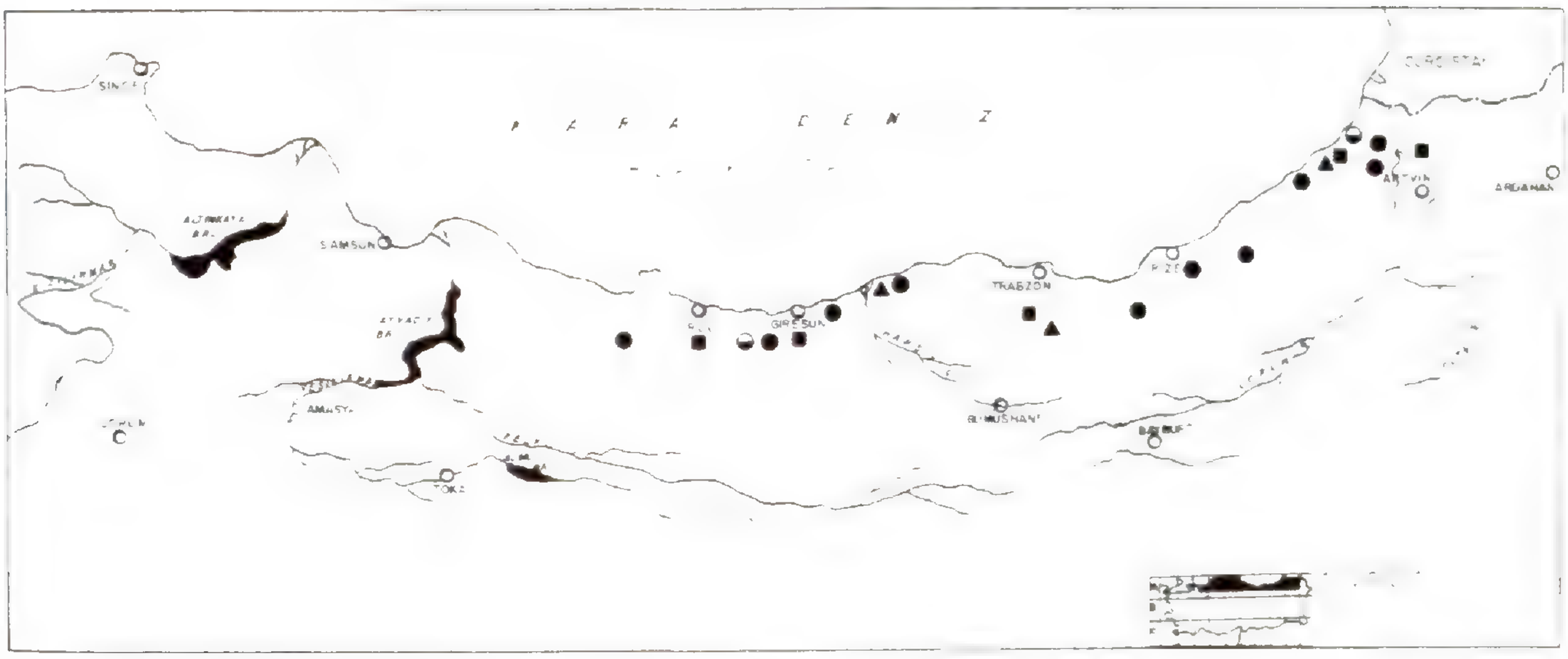

Figure 13: The distribution of *D. oreades*, *D. dilatata*, *D. expansa*, *D. filix mas* and *D. affinis* subsp. *borreri* in Eastern Black Sea region

▲ *Dryopteris oreades*
■ *Dryopteris dilatata*
● *Dryopteris expansa*
● *Dryopteris filix-mas*
◒ *Dryopteris affinis* subsp. *borreri*

WESTERN BLACK SEA REGION

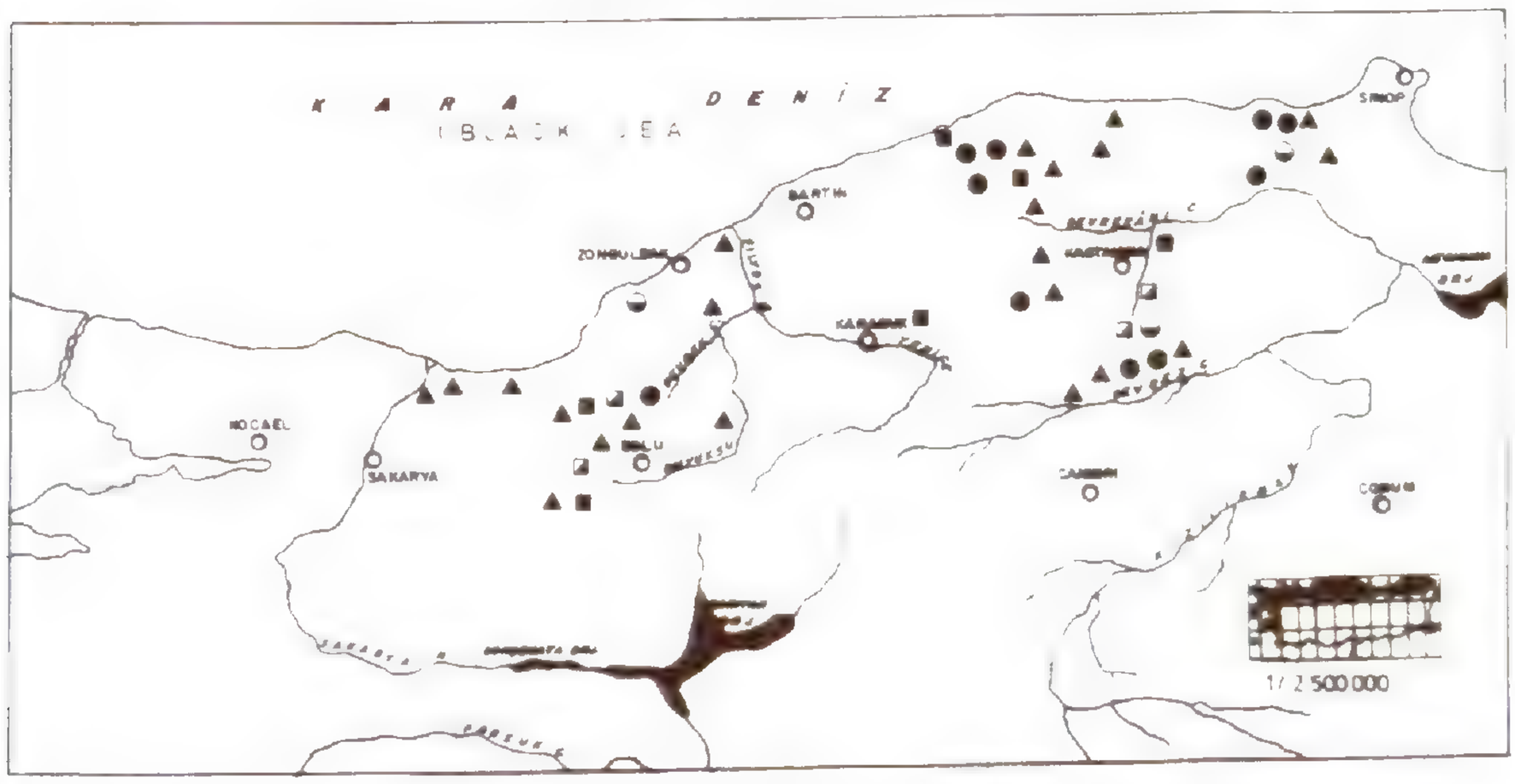

Figure 14: The distribution of *D. caucasica*, *D. affinis* subsp. *borreri*, *D. filix-mas*, *D. dilatata* and *Pteridium aquilinum* in Western Black Sea region

■ *Dryopteris caucasica*
◪ *Dryopteris affinis* subsp. *borreri*
▲ *Pteridium aquilinum*
● *Dryopteris filix-mas*
◒ *Dryopteris dilatata*

RESULTS AND DISCUSSION

About 450 fern specimens were collected from the research area between 1993-1995 and at the end of the studies 40 species belonging to 10 families and 18 genera were found. *Asplenium* contains 24.6 per cent of 450 fern specimens (111 samples) collected from the study area and is a genus including the most taxa (11 taxa) in the region. Other large families are Aspleniaceae (11 genera) and *Drypteridaceae* (11 taxa) (Table 1). *Polypodium vulgare* (Fig. 7,8), *Pteridium aquilinum* (Fig. 1, 14), *Asplenium trichomanes* subsp. *trichomanes* (Fig 7,8), *A. adiantum-nigrum*, *A. onopteris* (Fig. 6,10), *A. scolopendrium* subsp. *scolopendrium* (Fig. 7,8), *Athyrium filix-foemina* (Fig. 10, 11), *Polystichum setiferum* (Fig. 4,5) and *Dryopteris filix-mas* (Fig. 13,14) are the most widespread species in the area. Rare species are *Osmunda regalis*, *Cheilanthes marantae* subsp. *marantae*, *Cryptogramma crispa* (Fig. 1), *Gymnocarpium dryopteris* (Fig. 11), *Asplenium septentrionale* subsp. *caucasicum* (Fig. 9), *A. trichomanes* subsp. *quadrivalens* (Fig. 7), *A. viride* (Fig. 6), *Phegopteris connectilis* (Fig. 4) and *Woodsia alpina* (Fig. 12). When distribution of fern species was examined it was found that *Cryptogramma crispa*, *Phegopteris connectilis*, *Asplenium trichomanes* subsp. *quadrivalens*, *A. septentrionale* subsp. *caucasicum*, *A. cuneifolium* subsp.*woronowii*, *Woodsia alpina*, *Polystichum braunii*, *Dryopteris oreades* and *D. expansa* are distributed only in the east Black Sea region, *Pteris cretica*, *Oreopteris limbosperma*, *Matteuccia struthiopteris*, *Athyrium distentifolium*, *Gymnocarpium dryopteris*, *Dryopteris dilatata* in both central and east Black Sea region, *Polypodium vulgare*, *P. interjectum*, *P. australe*, *Adiantum capillus-veneris*, *Cheilanthes marantae* subsp. *marantae*, *Asplenium trichomanes* subsp. *trichomanes*, *A. adiantum-nigrum*, *A.onopteris*, *A.septentrionale* subsp. *septentrionale*, *A. ruta-muraria* subsp. *ruta-muraria*, *A. scolopendrium* subsp. *scolopendrium*, *A. ceterach* subsp. *ceterach*, *Athyrium filix-foemina*, *Cystopteris fragilis*, *Polystichum lonchitis*, *P. aculeatum*, *P. setiferum*, *P. woronowii*, *Dryopteris filix-mas*, *D. caucasica*, *Blechnum spicant* are distributed both in west, east and middle Black Sea regions. Earlier records of *Anogramma leptophylla* from A1 and A2 (Kaynak et al. 1996), were not confirmed (A7: TRABZON, A8: RIZE, Davis 1965), nor were records of *Hymenophyllum tunbrigense* in A8: ARTVIN (Davis 1988). RIZE: Fındıklı (AEF 13895).

Studies on the global distribution and ecology of ferns indicate a strong dependence on the chemical composition of the soil (Bailey 1969, Benlioğlu 1994, Bremer 1980 Gams 1938, Kaynak 1989, Kruckeberg 1965, Page and Clifford 1981, Schelpe 1964, Tryon 1957, Whrerry 1920, 1978). Observations from the ecological results based on soil and rock samples from the growth environment, as well as meteorological data, are in general agreement with the findings reported in literature. These results indicate certain preferences by the ferns to one or more of soil pH type, acidic, neutral or alkaline, as shown in Table 2. Furthermore, fern samples were classified according to the rock outcrops type to which they were attached, as calcicole or silicole and in some cases as highly tolerant types which grow on both rock types (Table 3). Accordingly, ferns growing on acidic soil types, *Osmunda regalis*, *Pteris cretica*, *Phegopteris connectilis*, *Asplenium trichomanes* subsp. *quadrivalens*, *A. cuneifolium* subsp.*woronowii*, *A. septentrionale* subsp. *septentrionale*, *A. septentrionale* subsp. *caucasicum*, *Matteucia struthiopteris*, *Athyrium distentifolium*, *Polystichum lonchitis*, *P. braunii*, *Dryopteris oreades*, *D. affinis* subsp. *borreri*, *D. expansa* and *Blechnum spicant* are classified as acidophil. On the other hand, *Adiantum capillus-veneris*, *Asplenium ruta-muraria* subsp. *ruta muraria*, *A. ceterach* subsp. *ceterach* are calcicol fern species which prefer to grow on alkaline soil types. These findings are in agreement with previous data in literature (Benlioglu 1994, Bremer 1980, Gams 1938, Kaynak 1989, Tryon 1957, Wherry 1920). However, *Polystichum lonchitis* has been reported to grow on alkaline soil rich in $CaCO_3$, in an artificially created forest in Holland (Bremer 1980).

According to the soil analysis, both *Asplenium trichomanes* subsp. *trichomanes* and *A. scolopendrium* subsp.*scolopendrium* which are frequent in the studied area, are tolerant of sub-acidic environments even though they are usually calcicoles.

Table 2. Classification of Black Sea Region Ferns on the Basis of Soil Reaction

Species	Total Specimen Number	%$CaCO_3$				pH	
		0-2	2-10	10-20	20<		
Osmunda regalis	2	2				3.8-4.4	acidophil
Adiantum capillus-veneris	7	1	2	2	2	7.2-7.7	basiphil
Pteris cretica	4	4				5.8-6.1	acidophil
Polypodium vulgare	12	4	8			6.0-7.7	neutrophil
Polypodium interjectum	8	5	3			6.0-7.6	neutrophil
Polypodium cambricum	6	4	2			5.3-7.7	neutrophil
Pteridium aquilinum	60	28	20	9	3	5.5-7.8	neutrophil
Phegopteris connectilis	2	2				4.5-4.9	acidophil
Oreopteris limbosperma	12	9	3			4.5-7.8	neutrophil
Asplenium trichomanes subsp. *trichomanes*	28	16	8	4		4.7-7.8	basiphil-neutrophil
Asplenium trichomanes subsp. *quadrivalens*	2	2				4.9-6.8	acidophil
Asplenium adiantum-nigrum	16	13	2	1		4.7-7.7	acidophil-neutrophil
Asplenium onopteris	12	8	4			4.7-7.6	acidophil-neutrophil
Asplenium cuneifolium subsp. *woronowii*	1	1				5.2	acidophil
Asplenium septentrionale subsp. *septentrionale*	2	2				5.3-5.6	acidophil
Asplenium *septentrionale* subsp. *caucasicum*	2	2				5.3-6.2	acidophil
Asplenium ruta-muraria subsp. *ruta-muraria*	4			3	1	7.1-7.7	basiphil
Asplenium ceterach subsp. ceterach	6	1	3	2		6.2-7.8	basiphil
Asplenium scolopendrium subsp. *scolopendrium*	17	11	4	2		4.7-7.7	basiphil
Matteucia struthiopteris	7	7				4.9-6.1	acidophil
Athyrium filix-foemina	22	20	2			4.7-7.6	acidophil
Athyrium distentifolium	4	4				5.1-6.9	acidophil
Cystopteris fragilis	5	5				6.2-6.5	neutrophil
Polystichum lonchitis	3	3				5.0-5.2	acidophil
Polystichum woronowii	3	3				6.8-7.3	neutrophil
Polystichum aculeatum	10	7	3			6.8-7.6	neutrophil
Polystichum braunii	2	2				5.0-6.1	acidophil
Polystichum setiferum	20	12	6	2		4.7-7.6	neutrophil
Dryopteris oreades	3	3				3.8-5.6	acidophil
Dryopteris caucasica	2	1	1			5.4-7.7	neutrophil
Dryopteris filix-mas	7	7				4.7-7.2	acidophil
Dryopteris affinis subsp. borreri	3	3				5.3-6.4	acidophil
Dryopteris dilatata	3	2	1			4.4-7.7	acidophil
Dryopteris expansa	1	1				4.4	acidophil
Blechnum spicant	6	5	1			5.5-7.6	acidophil

Table 3. Substrata of Black Sea Region Ferns.

Fern species	Approximate mean annual rainfall range of known habitats in Black Sea Region (mm)	Calcareous rocks*									Silica rocks*								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Adiantum capillus veneris	401.1-1297.8	+				+					+		+						
Polypodium vulgare	533.7-2357	+		+			+		+					+			+		+
Polypodium interjectum	628.8-2357	+							+						+				+
Polypodium cambricum	1169.6-1297.8							+					+						
Pteridium aquilinum	446.1-2357	+		+		+	+		+			+	+		+		+		+
Phegopteris connectilis	433.4-822.7										+								
Oreopteris limbosperma	1713.4-2357										+		+				+		
Asplenium trichomanes subsp. *trichomanes*	401.1-2357	+		+			+		+	+	+	+	+		+		+		+
Asplenium trichomanes subsp. *quadrivalens*	1713.4-2357										+								
Asplenium adiantum-nigrum	533.7-2357					+			+		+		+				+		+
Asplenium onopteris	664.4-2357	+		+			+			+			+		+		+		+
Asplenium cuneifolium subsp. *woronowii*	731.6-2357															+			
Asplenium septentrionale subsp. *septentrionale*	434.3-2357		+					+											
Asplenium septentrionale subsp. *caucasicum*	433.4-2357	+					+												
Asplenium ruta-muraria subsp. *ruta-muraria*	434.3-1242.9	+																	
Asplenium ceterach subsp. *ceterach*	401.1-1242.9	+																+	
Asplenium scolopendrium subsp. *scolopendrium*	645.0-2357	+		+			+		+						+		+		+
Matteuccia struthiopteris	446.1-2068.8						+												
Athyrium filix-foemina	449.7-2357	+								+		+	+				+		+
Athyrium distentifolium	792.8-2357										+								
Gymnocarpium dryopteris	792.8-1169.6										+								
Cystopteris fragilis	401.1-822.7						+												
Woodsia alpina	433.4-822.7						+												
Polystichum lonchitis	533.7-822.7										+					+			
Polystichum aculeatum	645.0-2357	+									+				+				
Polystichum braunii	792.8-2357										+								
Polystichum setiferum	792.8-2357	+		+	+		+			+		+			+		+		+
Dryopteris oreades	645.0-1759.8															+			
Dryopteris caucasica	449.7-628.8								+										
Dryopteris filix-mas	679.6-2357			+	+		+					+							
Dryopteris dilatata	449.7-1242.9												+						
Blechnum spicant	785.4-2357																+		
Asplenium viride	735.0	+																	

*1. Limestone, 2. Crystalline limestone, 3. Marl, 4. Conglomerate, 5. Calc-tufa, 6. Andesite, 7. Aplite, 8. Basalt, 9. Diabase (Dolorite), 10. Granite, 11. Quartzite, 12. Limonite, 13. Pegmatite, 14. Peridodite, 15. Riyolite, 16. Silica-sandstone, 17. Talc (Steatite), 18. Ultramafic tuff.

Polypodium vulgare, *P. interjectum*, *P. cambricum*, *Cystopteris fragilis*, *Polystichum woronowii*, *P. aculeatum* and *Dryopetris caucasica* were found to be neutrophil fern types, growing both on acidic and alkaline soil (see also Bailey 1969, Benlioglu 1994, Bremer 1980, Gams 1938, Kaynak 1989, Page and Clifford 1981, Schelpe 1964, Wherry 1920). At the same time, soil analysis for *Oreopteris limbosperma*, *Athyrium filix-foemina*, *Polystichum setiferum*, *Dryopteris filix-mas* and *D. dilatata* indicate these are acidophil ferns, but are partially tolerant to alkaline conditions (Table 2). Similarly, studies in Northern Wales and the Netherlands reported that these fern types can grow on alkaline soils (Bremer 1980, Page and Clifford 1981).

In addition, *Pteridium aquilinum*, *Asplenium adiantum-nigrum* and *Asplenium onopteris*, which are widely distributed fern species in the study area, exhibit growth on all acidic, alkaline and pH-neutral soil environment (Table 2). *Pteridium aquilinum* is ecologically the most tolerant fern species, and is reported to exhibit growth on soils with pH between 3.2 and 7.6 (Gams 1938).

Adiantum capillus-veneris, *Asplenium viride*, *A. ruta-muraria* subsp. *ruta-muraria*, *A. ceterach* subsp. *ceterach* are both calcicole and casmophyte fern growing only in fissures on limestone. In contrast, *Gymnocarpium dryopteris*, *Asplenium septentrionale* subsp. *septentrionale*, *A. septentrionale*, subsp. *caucasium*, *Woodsia alpina* and *Polystichum lonchitis* are silisicole casmophyte fern species, and grow only in the fissures of rocks rich in silica like andesite, granite, quartz, limonite. *Asplenium trichomanes* subsp. *trichomanes*, the other casmophyte fern species in the area, grows in the fissures of both calcium and silica rich rocks (Table 3).

Some fern species in the area were observed to grow usually on the north facing side of rocks, in the shade at the bottom and in the immediate vicinity of rocks. Among these species, *Asplenium scolopendrium* subsp *scolopendrium* grow in the forest undergrowth on limestone especially under *Fagus orientalis*, *Castanae sativa*, *Alnus glutonisa*, *Abies* and *Taxus*. In contrast, *Phegopteris connectilis*, *Oreopteris limbosperma*, *Asplenium trichomanes* subsp. *quadrivalens*, *A. cuneifolium* subsp.*woronowii* , *Matteucia struthiopteris*, *Polystichum braunii* are widely distributed on silica rich rocks. *Polypodium vulgare*, *P. interjectum*, *Pteridium aquilinum*, *Asplenium onopteris*, *A. adiantum nigrum*, *Polystichum aculeatum*, *P. setiferum* and *Dryopteris filix-mas* grow on, under and in the vicinity of both silica and calcium rich rocks (Table 3). Soil and rock samples could not be obtained for *Cryptogramma crispa* and *Cheilanthes marantae* subsp. *marantae* .

In addition, observations in the area established that *Athyrium filix-foemina*, *Polystichum setiferum*, *P. aculeatum*, *P. woronowii*, *Dryopteris filix-mas*, *D. oreades*, *D. affinis* subsp. *borreri*, *D. dilatata*, *D. expansa*, *Blechnum spicant*, *Cystopteris fragilis*, *A. scolopendrium* subsp. *scolopendrium*, *Oreopteris limbosperma* and *Matteucia struthiopteris* generally grow together in forest undergrowth and along shady streams. In areas rather more exposed to sunlight are *Asplenium onopteris*, *A. adiantum-nigrum*, *A. trichomanes* subsp. *trichomanes* and *Pteridium aquilinum* , *Oreopteris limbosperma*, *Athyrium filix-foemina*, *Dryopteris filix-mas*, *D. affinis* subsp. *borreri* and *Blechnum spicant* grow together in abundance.

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BOOK REVIEWS

HOLTTUM MEMORIAL VOLUME.

R.J. Johns (ed.) 1997. viii + 272 pp. Royal Botanic Gardens, Kew.
Price £30.00. ISBN 1 900347 17 2. Paperback.

This book was published to commemorate the centenary of the birth of Dr. Richard Eric Holttum, a leading pteridologist of the 20th century. The book is a compilation of 17 original research articles by different authors dealing with various aspects of pteridology. In the introduction, W. Stearn summarizes the life of Professor Holttum, his important contribution to the study of ferns and orchids as well as his interesting religious insight. A very helpful list of Professor Holttum's 593 publications follows. The impressive bibliography of Dr. Holttum's publications spans 77 years of scientific research, beginning with his first article in 1919 and ending with a posthumous article published in 1996. Subsequent articles deal with different aspects of spore morphology, its development and its importance in taxonomy, paraphysis morphology, phytogeography and diversity of pteridophytes in Borneo and the West Indies, ethnobotany of ferns, and DNA analysis. The reader will find interest in the article by D. B. Lellinger and W. C. Taylor where the authors attempt to standardize spore ornamentation terminology. The use of spore characters in solving taxonomic problems has become more common as scanning electron microscopes become more affordable. B. S. Parris presents a helpful classification of the receptacular paraphysis of Asia-Pacific Grammitidaceae. Parris's work is also a useful step towards the standardization of paraphysis classification.

Botanists working with Neotropical ferns will be interested in the review of West Indian species of *Polystichum* by John Mickel and the conclusions he makes about the evolutionary relationship of the group with east Asian species; the notes of New World *Salvinia* species; the importance of the epispore as diagnostic character; and the phytogeographical analysis of the pteridophytes of Veracruz, Mexico. The evaluation of threatened species of Cuban pteridophytes prepared by C. Sánchez-Villaverde and M.G. Caluff is a valuable addition to the knowledge of the rich flora of this beautiful island and to the future of conservation of the Cuban flora. C. D. Adams presents a very interesting account of historical detective work in clarifying the nomenclature of *Polypodium trinidadense*, which is not from Trinidad but a common Asiatic species. The DNA study on Central and South American Cyatheaceae presented by Stein *et al.* evaluates the phyletic hypotheses of Holttum, Tryon and Lellinger. It provides contemporary thinking on the use of molecular data to help understand phylogenetic relationships.

The interesting and stimulating work of R.S. Beaman and J.H. Beaman shows the great possibilities of Geographical Information System Technology (GIS) in understanding and evaluating vegetation patterns. Their use of GIS in analyzing the diversity and distribution of the ferns of Mount Kinabalu, Borneo, is a good example of how modern technology can be of great use in the evaluation and management of natural resources. The study by S. Wu on the ferns of Wuling, China, reveals the great number of species, genera and families of ferns found in the mountainous region. Bao and his colleagues conducted an in-depth study of the gametophyte development of *Thelypteris palustris* and *Phegopteris polypodioides*. H. Christensen presents an interesting ethnobotanical study with surprising results on the many and frequent uses of ferns by two indigenous tribes of Sarawak, Borneo. Topics on North American and European ferns were not included.

Pteridophytes are the common denominator of the articles in this book; otherwise, the articles do not have a common theme. Spore studies are the dominant group of papers, with five articles in total. Readers interested in spore morphology and development will find the ideas presented here appealing and helpful. The variety of topics will interest the botanist who has a broad range of research preferences and wants to know what is being done in other regions of the world. This is a beautifully printed book with many quality photographs and articles of interest to botanists on various aspects of pteridology. Professor Holttum would certainly have been very pleased with the quality of the work presented here.

A. Edward Salgado

PTERIDOLOGY IN PERSPECTIVE.

J.M. Camus, M. Gibby and R.J. Johns (eds)1996 xx+ 700pp. Royal Botanic Gardens, Kew.
Price £60.00. ISBN 1 900347 09 1. Hardback.

This monumental seven hundred page book contains 76 chapters resulting from the papers and posters presented at the Holttum Memorial Pteridophyte Symposium held at Kew in 1995. Held a century after the birth of Richard Eric Holttum, the symposium celebrated his remarkable contribution to the study of ferns and their allies. The first of the six major sections in the book contains two chapters giving vivid accounts of Holttum's achievements during 95 years of life.

The book itself is also a monumental achievement. It truly puts the discipline of pteridology in perspective, showing it to be an exciting and rapidly developing field of science. The inclusion of many short contributions, based on posters, helps maintain the diversity and vitality of the book and is an approach other symposium organisers should chose to follow.

The second section of the book deals with Floras, Biodiversity and Conservation. The most important message is that pteridophytes have been neglected: in conservation projects, in scientific reference collections and in published identification manuals. As V.B. Amoroso *et al.* point out, it is probably not surprising that the public attention focused on the destruction of tropical forests does not include awareness of the consequences for forest-dwelling ferns. The vulnerability of delicate plants such as filmy ferns (C. Sánchez & M.G. Caluff), of island fern floras (Y.S. Baksh-Comeau) and of desirable house plants (G.L. Unwin and M.A. Hunt) are all carefully documented. Despite the quality of these, and other case histories, it is clear that we still do not know enough about ferns for their, or our own, good even in this era of biodiversity. The urgent plea by M. Roos for more floristic research, especially in the tropics, is well argued while B. Lèon and K.R. Young illustrate the plight of pteridology in Peru. There are probably fewer than 10,000 herbarium specimens representing the 1,060 species of pteridophytes so far recorded from Peru. The majority of these are in collections outside Peru, a country that currently has no full time professional pteridologists. The Convention on Biological Diversity calls for the sharing of resources and international collaboration in the development of scientific capacity. A crash-programme to train pteridologists in the tropics is clearly needed!

Two chapters in this section that I found particularly novel are the investigation of soil spore banks by A.F. Dyer & S. Lindsay and the application of molecular biology to discover levels of genetic variation at the population level by F.J. Rumsey *et al.*

The third section concerns Generic and Family Concepts and here the chapters by P.G. Wolf, J. Pahnke *et al.*, D.S. Conant *et al.* and J.-Y. Dubuisson show the spectacular advances that have resulted from molecular systematics in recent years. Similarly, the chapter by Stevenson and Loconte in a later section shows the rapid progress now taking place in phylogenetic studies of pteridophytes. Despite the technical difficulties enumerated by P.G. Wolf, molecular sequence data can clarify relationships at various levels within pteridophytes, and is especially effective when fully integrated with morphological characters. Given the rapid progress of phylogenetic analysis, which is demonstrated by the growing robustness of many groupings, E. Hennipman's proposal for a consensus classification seems somewhat discordant.

Section four concerns Species Concepts and Speciation. I particularly enjoyed C. Haufler's thought-provoking contribution of a chapter that merits reading by all biologists, whatever their specialism. Once again, molecular approaches are opening up exciting new avenues for research in pteridology as J.C. Vogel *et al.* show in their unravelling of reticulate evolution in *Asplenium*. Both this chapter and that of J.E. Burrows, on *Ophioglossum* in sub-Saharan Africa highlight relationships between fern distributions and geology. This is surely a fruitful area for future research.

Section five, entitled Pattern and Process, deals with the fossil record and aspects of pteridophyte ultrastructure. A minor niggle from me is that I would prbably have grouped the papers with those in section three. However, as in other parts of the book the quality of the contributions is excellent. M.E. Collinson's review of fossil pteridophytes is outstanding and will now be the natural place to begin for anyone wishing to delve into the palaeobotany of

pteridophytes. G.W. Rothwell's account of fossil ferns and R.M. Bateman's overview of lycophytes are both masterly treatments that show the value of integrating studies of Recent and fossil plants. This is especially important in the case of such ancient plants, which have dominated the vegetation throughout much of history and where the fossil record reveals many living species to be the survivors of much more abundant and diverse lines.

The morphological and ultrastructural chapters serve to emphasise how much scope remains for the careful documentation of organisation and ontogeny in biology.

The sixth and final section of the book concerns Interaction with the Environment and Other Organisms and rounds off the book neatly with contributions on life cycles, ecology, population genetics and physiology.

The editors are to be congratulated on producing an excellent book that is certain to be used as a key source of information for many years to come. It is a volume that deserves to be read by many people outside the field of pteridology. It should be compulsary reading for those biologists foolish enough to believe that most of organismal biology had been completed before Holttum was even born.

Stephen Blackmore,

THE FERN GAZETTE

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Manuscripts on any aspect of pteridology are welcome and should be sent to:

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